Report 2090

CAMOUFLAGE PATTERN PAINTING REPORT OF USAMERDC'S CAMOUFLAGE SUPPORT TEAM TO MASSTER

by

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* This report presents the activities, findings, and conclusions of a MERDC Camouflage Team on pattern painting of Army vehicles. The investigation was conducted during 1972 and 1973, in conjunction with MASSTER, at Fort Hood, Texas, and involved pattern painting both by troops and professionals, in motor pools and maintenance shops. Among the topics discussed are pattern theory and application, paints and painting, cost, and results for both ground vehicles and helicopters.		

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CAMOUFLAGE PATTERN PAINTING REPORT OF USAMERDC'S

CAMOUFLAGE SUPPORT TEAM TO MASSTER

I. INTRODUCTION

1. **Background.** The cooperative camouflage program between MASSTER and MERDC was first initiated under a directive on 10 December 1971 from AMC to CO, MERDC, and was the result of a TPIPR on MASSTER ACCB II/TRICAP I chaired by the Assistant Vice Chief of Staff, U.S. Army, on 9 December 1971. On 13 and 14 December 1971, Adolph H. Humphreys and James Carney of MERDC visited MASSTER to determine the nature of the camouflage problem. A state-of-the-art briefing and a proposed program were presented to MASSTER on 5 January 1972 by a team from MERDC. This meeting with MASSTER resulted in a demonstration during ACCB II/ TRICAP I and a camouflage evaluation of the same exercise. The results were reported at a conference held at MASSTER on 18 March 1972 attended by representatives of AMC, MASSTER, CDC, CONARC, and U.S. Army GS and recorded in USAMERDC Report 2028 "Camouflage Team Report of MASSTER ACCB II/TRICAP I," dated April 1972.

In April 1972, as a result of a letter from OACSFOR to CG, AMC, dated 4 April 1972, subject: "Camouflage" and a TWX from DA to MASSTER dated R232026Z, Mar 72 ZFF3, subject: "Camouflage," a joint effort was established between MASSTER and MERDC to implement a camouflage program at Fort Hood. A MERDC Camouflage Team, to provide on-site technical advice and support to MASSTER, was formed in April. Team members were Adolph H. Humphreys, Team Chief; SFC (E7) Donald Howell, Camouflage Specialist; Ralph Thompson, Engineer; Sharon Jarvis, Engineer/ Designer; George Hinkle, Camouflage Technician; and Judy Stahle, Engineer Aide. This team immediately initiated planning, designing, and procurement of materials, proceeded to Fort Hood in August 1972, and remained there until March 1973. A second team, at MERDC, served as the focal point to support the on-site team and was composed of Kemper Flint and SFC (E7) Francis Rea. Both teams were supplemented as required for specific tasks to insure prompt and responsive action to program needs.

A series of meetings was held between Mr. Humphreys of MERDC and Fort Hood personnel representing the Materiel Test Directorate of MASSTER, III Corps, the 2nd Armored Division, and the 2nd Brigade/2nd AD. Included from MASSTER were LTC Edward Endres, LTC Alan Laubscher, MAJ Richard McDermott, and MAJ Gilberto Marrero, the Project Officer. From these meetings, a program was developed for the evaluation of a number of camouflage materials and equipment. Camouflage pattern painting was one of the evaluations of Phase I covering camouflage problems from the

FEBA to the Brigade rear boundary. In June 1972, the 2d Bde (St. Louis)/2d AD was selected as the test brigade by the CG, III Corps.

This report deals only with camouflage pattern painting. Because of the joint nature of the program, the MERDC report and the MASSTER Evaluation, particularly extracted portions included as Appendix II, must be considered as mutually supporting documents when decisions are made on pattern paint and the outcome of the work at Fort Hood. The contents of both reports have been coordinated between the two agencies.

II. INVESTIGATION

2. **Purpose.** The purpose of this report is to present the basic concept of pattern painting as a camouflage art and the technical and design considerations important in the investigation.

3. **Concept of Pattern Painting.** All military vehicles and equipment have regular geometric configurations or characteristic shapes and interior shadows. These so-called signatures contrast with natural surroundings and make the object conspicuous. Pattern painting contributes significantly toward disrupting the signature characteristics by using lusterless paint to reduce the glare of highlights, color to reduce contrasts with the soil and vegetation, and shape to distort the vehicle's geometric lines and overall configuration. Pattern painting is an art and not a precise science. The camoufleur designs the pattern according to each vehicle's needs with color areas that cut off corners, avoid straight, vertical, and horizontal lines; and extend internal shadows in shapes similar to natural features and vegetation.

Pattern painting is not a magic, cure-all camouflage technique. However, it materially reduces the threshold of visibility of the item and its recognition characteristics as a military object; it also provides an excellent base for further, more complete camouflage. If properly sited, the pattern-painted vehicle will require less effort to camouflage than a solid-colored vehicle. Figures 16 through 20 show pattern-painted vehicles under various field circumstances during exercises and evaluations at Fort Hood. (All figures appear in Section V.)

The theory behind this new, experimental, pattern-painting design is to provide a system that can accommodate by the changing of one or, at most, two colors geographical and seasonal changes; for instance, changing the forest green to sand for desert operations or changing the field drab to dark green and the sand to field drab for summer, verdant terrains in temperate climates. The pattern used at Fort Hood (forest green, field drab, sand, black) may be used for fall and winter in verdant terrains and terrains subject to drought or long dry seasons (see Table 1 for color distribution).

Table 1. Average Color Distribution for Ground Vehicles and Helicopters

Vehicle	Field Drab (%)	Forest Green (%)	Sand (%)	Black (%)	Total Area (Sq ft)
M109 Howitzer	49.8	42.0	3.6	4.6	490.8
AH 1 Cobra	42.0	38.9	14.2	4.9	752.6
UH 1 Huey	37.5	38.9	19.0	4.6	332.2
M60 Tank	46.6	43.5	5.6	4.2	651.4
M35A2 2½t Truck	45.6	45.2	4.7	4.5	433.6
M113 APC	44.8	44.9	7.0	3.3	355.2
Average for ground vehicles	46.7	43.9	5.2	4.2	

By using the color from the camouflage color chart (TM 5-200, Fig. 51) in conjunction with the pattern-painting design, a good standard coloration for almost every terrain can be achieved. Figures 13, 14, and 15 show vehicles in the motor pool in the colors they were painted at Fort Hood.

These new MASSTER/MERDC designs will also lend themselves to "touch-up" painting without the unsightly mottling which results from "touch-up" of the current OD vehicles. Slight mismatches in color will not be as noticeable as they are on a solid-colored vehicle except from very close inspection. Likewise, minor abrasions and scaling of surfaces will be equally inconspicuous.

4. **Design Considerations for Pattern Painting.** In late April 1972, it was established that camouflage pattern painting would be one of the items for evaluation and that designs for preliminary evaluation and demonstration to CG III Corps; Dep CG, MASSTER; CG 2d AD; and Cdr 2d Bde (St. Louis) would be available in June and that the design selected from this evaluation would be used to paint elements of the 2d Bde (St. Louis).

The following considerations were used in developing the designs:

a. Develop a pattern with maximum effectiveness from ground and air observation in the target-acquisition role.

b. Develop a pattern which can be applied by troops with minimum training and effort using the minimum amount of special equipment (if possible, no special equipment).

c. Develop a pattern with maximum effectiveness under combat conditions but which also presents a good military appearance in garrison.

d. Develop a pattern which uses colors from the standard camouflage chart (TM 5-200, Fig. 51) and thus avoids color mixing or tinting in the field to achieve the specified color.

e. Design the patterns to be mutually enhancing when combined with other camouflage techniques such as natural foliage applied in brackets.

f. Create a design which will permit the changing of one or two colors to accommodate seasonal and geographic changes (and which will avoid the need to completely repaint the vehicle for such changes).

g. Create a design in which the paint may be easily retouched without creating unsightly mottling or color mismatches.

h. Avoid design systems which require precise execution of the line and shape of the individual patterns.

i. Use paints which are obtainable in the federal stock supply system insofar as possible and which are easily applied, quick drying, and compatible with the original paint as substrate.

j. Create a system that would lend itself to application both by soldiers and by industry.

III. DISCUSSION

5. Initiation of the Program. Preliminary designs, two versions for each of three vehicles: the M60 Tank, the M109 (155 SP How), and the M113 APC were completed; vehicles were painted for a demonstration at Fort Hood in June 1972 (Fig. 1). SFC Howell trained the painting crew and supervised the painting of the demonstration vehicles in the motor pools of the 1/66 Armored Bn and the 1/14 Art Bn. The demonstration took place as scheduled and was viewed by officers of III USA Corps, 2d AD, and MASSTER including MG Shoemaker, DCG, MASSTER; and COL McSpaddin, Commander, 2d Bde, 2d AD. This demonstration resulted in the selection of the pattern on which the future designs were based. Subsequently, the decision was made that the entire 2d Bde would be pattern painted, and vehicle pattern designs were initiated on 52 vehicles and 3 helicopters.

The first three helicopters (1 Cobra AH1, 1 Huey UH1, 1 Kiowa OH58), using patterns after the same basic design as the demonstration vehicles, were painted at Fort Belvoir and ferried to MASSTER on 1 August 1972 for a demonstration and initiation of the painting program at Fort Hood (Fig. 2).

6. **Training.** The MERDC Camouflage Support Team designed the following 3-day training program:

a. A brief, approximately ½ hour, lecture on the purpose of camouflage painting at which time handouts were presented to the NCO's in charge. Copies of the handouts are contained in Appendix IV.

b. Demonstration, approximately 2 hours:

(1) Cleaning of surfaces for painting.

(2) Masking of lenses, periscopes, windshields, and critical items to avoid damage from paint.

(3) Paint mixing (instruction sheets on each type of paint were provided (see Appendix IV).

(4) Application of patterns to vehicles.

(5) Use and cleaning of spray equipment and brushes.

(6) Painting techniques with both spray gun and brushes.

c. Practical exercise which consumed about 2½ days in which the various elements under para. b(1) through (6) were supervised by members of the team. This overall training procedure was very effective. Most painting teams were sufficiently proficient in 2½ days to be released to their own NCO's; only a few required additional days under the camouflage team's supervision. Subsequently, members of the camouflage team made daily visits and gradually reduced these visits to once or twice a week depending on the proficiency of the painting team. The camouflage team remained on call throughout the period 1 August 1972 to February 1973 to assist in difficult or unusual problems.

Without exception, the officers and men displayed enthusiasm for the program once they understood the purpose. As time progressed, they volunteered suggestions and initiated changes within their own working environment to facilitate the job. The enthusiasm of the troops was a major factor in completing approximately 1400

vehicles by 15 January 1973. In all, over 30 painting crews were trained by the MERDC Camouflage Support Team.

The Commander of 2d Bde, 2d AD, published a letter, subject: Vehicular Marking – Camouflage Vehicles, which provided the policy for the painting and marking of vehicles in the brigade. (A copy is attached as Appendix III.)

7. **Design Drawings.** Except for a few key vehicle patterns—M60, M113, M151—and three helicopters, which were made at Fort Belvoir, all of the pattern-painting designs were done by the MERDC Camouflage Support Team while at Fort Hood. Each design was made, then applied to a vehicle. A member of the team observed the application of the design to the first three to five vehicles to locate features causing difficulty in marking or painting the vehicle. Based on these pilot vehicles, changes were immediately made to the master drawings; and this revision was then disseminated to all the units requiring pattern-painting designs for the particular vehicle. Subsequently, the vehicles, as painted by the units, were inspected for uniformity of the patterns and for camouflage characteristics. Changes were made where necessary to insure easier conformance to drawings and/or to enhance both uniformity of appearance and camouflage value. (See Appendix IA and IB, separately bound, and Fig. 3, the composite drawing of a pattern-painting design for the M113.)

8. **Vehicle Preparation.** It was difficult to impress on each new paint detail the need for a clean surface. Initially, the soldiers' idea of a clean surface for painting was far short of that required. Consequently, the first few vehicles produced by each paint detail displayed deficiencies directly attributable to poorly prepared surfaces. Figure 4 shows soldiers cleaning a vehicle in the wash rack.

Vehicle preparation is extremely important and should be supervised with the utmost care. All grease, oil, dirt, plastic letters and stars, all loose and scaling paint, and paint other than the original enamel or lacquer (such as latex paints, etc, which may have been used to retouch as an expedient) must be removed from the vehicle or aircraft. The vehicle must be steam cleaned with detergent or with solvent and rinsed thoroughly to insure a clean surface suitable for a durable coating. Sanding the rough areas to remove the scaling and oxidized surface from the old paint will also increase the quality and durability of the new paint job (Fig. 5).

Helicopters become coated with battery acid from the battery overflow vent in addition to the normal kinds of surface dirt (oil, oxidation, dust, peeling, etc). The acid must be neutralized with a bath of sodium bicarbonate (three handfuls per bucket of water). The entire helicopter must be washed generously with this mixture and thoroughly rinsed when finished. Anything less than this treatment will result in peeling, cracking, and scaling of the new coating. All glass, grease fittings, and items which

can be damaged by paint must be masked with masking tape and/or paper. Grease should be used for masking only as a last resort because it can be easily smeared onto other parts of the vehicle or helicopter and can prevent paint adhesion.

9. **Application (Marking) of the Patterns to Vehicles or Helicopters.** Several approaches to applying patterns to the vehicles were evaluated prior to the initiation of pattern-painting designs at Fort Hood in August 1972. The approaches analyzed were: (a) templates for each vehicle; (b) measurement (dimensions) for precise location of patterns; and (c) application of patterns using a proportional method and reference points.

a. **Templates.** This process employs templates cut to the shape of each color area for the particular vehicle to insure accurate application of the pattern. This system has considerable virtue on simple shapes, cubes, or spheres but gets very complicated where complex vehicle configurations are involved. Large numbers of intricate patterns would be required for a vehicle such as the M60 tank – each pattern keyed to a particular spot on the vehicle. This process was discarded as complicated and unmanageable by troops painting vehicles such as in the case encountered at Fort Hood.

b. **Measurement (Dimensions).** This method envisions dimensional drawings from which the pattern could be laid out on the vehicle. Such a system would have the advantage of precise location of each pattern; and, therefore, uniformity of the patterned vehicles would be assured. Work with this system indicated the requirements for large numbers of dimensions; and, in the case of a free-form design, it would require complex radii. Additionally, the application of patterns to vehicles using this method would be extremely time-consuming and more precise than required. This system was discarded as too complicated for troops, too time-consuming, and unnecessarily precise for good camouflage.

c. **Proportional.** This process uses reference points on the vehicle, a free-form shape, and the proportions of the vehicle in applying the pattern. Previous experience with pattern painting using a variety of designs indicates that high precision is not required if the integrity of the shape and size of the patterns is maintained within reasonable tolerances relative to the details within the silhouette of the vehicle. This system was used by SGT Howell to check the validity of our desk analysis during the preparation of the demonstration vehicles in June 1972 at Fort Hood. It was also used in applying patterns to three helicopters at Fort Belvoir in July 1972. Both of these trials indicated that the system was easy to comprehend after a demonstration of the technique and a practical work exercise. The method was adopted as the one around which the team's patterns would be designed for the evaluation in the MASSTER Phase I Camouflage Program. Subsequent experience in the painting of over 1400

vehicles and 50 helicopters (by February 1973) continued to validate our findings. It is also noteworthy that the level of education of the soldier has little to do with his ability to learn the process or the time it takes to teach him how to mark the patterns on a vehicle. In fact, we found that about four out of five soldiers could do a creditable job after marking off one vehicle under supervision.

Drawings for the vehicle are essential except where a camoufleur of considerable experience is available or where a sample vehicle is available to be copied. Although precise measurement of pattern boundaries is not necessary, gross inaccuracies will result in a deterioration of effectiveness. The patterns are designed in such a way that tolerances of ±2 inches (rule of thumb measurement) will not grossly affect the quality of the pattern. Care must be exercised to avoid, wherever possible, straight, vertical, and horizontal lines. The pattern is applied to the vehicle with an abbreviation of its color (paint-by-the-numbers) to guide the painters. Figure 6 shows a soldier applying a pattern to an M577 with chalk. Subsequently, the painters *must* wipe the chalk markings off the surface as they paint or the markings will show through the new paint job and cause poor adhesion along the chalk lines.

10. Vehicle Painting Methods. The three methods of applying paint that were evaluated for use in the pattern painting of vehicles are described in the following paragraphs.

a. Roller Application. This method was evaluated at Fort Belvoir prior to the Fort Hood exercise. It uses considerably more paint than the brushing method and is more difficult because of rounded surfaces, corners, and small appendages. Application of the paint over large, flat surfaces is rapid; but the effort required in corners, on rounded objects, and around ancillaries negates any time gained by the method. Consequently, the method was discarded before the team departed for Fort Hood.

b. Brushing. This method is a practical approach because brushes are readily available both in self-service stores (supply) and on the local, commercial market. The brush sizes used in the evaluation were the ½-inch artist brush and 1-, 2-, 4-, and 6-inch common painter's brushes. In general, we found that most soldiers had little or no skill in brush painting despite the universal acceptance of this method in civilian practice. Very few could draw regular lines along the boundaries of the colors or understand how to spread the paint using brush strokes. Usually, they employed the brush more like a scrubbing brush. These deficiencies were overcome by a short training period and individual tutoring as the job progressed. The painted surface obtained by the brush method, although acceptable, resulted in a higher gloss than the roller or spray method. The brush method did use less paint than the roller method, but it was not as economical as the spray method.

c. **Spray Painting.** With only a few exceptions, the soldiers had never used paint-spraying equipment. However, after a brief training period, they rapidly gained skill during practical work. Figure 7 shows a soldier outlining the pattern and filling in the field drab color. In general, after painting two or three vehicles, the painters' level of skill reached a point where the quality of the surface was sufficiently acceptable to discontinue close supervision. The quality of the coating and pattern became progressively better with time on the job. After a couple of weeks experience, a paint detail was applying a quality coating in acceptable thickness and appearance and was using acceptable amounts of paint. Figure 8 shows a soldier finishing a vehicle. (See Appendix II, MASSTER Evaluation (Extract), for the average paint and man-hours per vehicle of the various types.) Spray painting was adopted as the most economical in gallons of paint required, and it was the general consensus that the overall appearance of the spray-painted vehicle was more professional. Brush painting of the black figures in the pattern was a general practice until a high degree of skill was achieved with spray guns. Figure 9 shows this operation. A small amount of brush painting was also employed in places difficult to reach with spray equipment and to speed up work in the absence of sufficient spray guns.

d. **Touch-up Painting.** Retouch painting is closely allied to the problem of durability and appearance. It can be accomplished with the same methods as painting with brush or spray gun. Small areas needing "touch-up" paint may be redone most economically and quickly with a brush; however, if extensive retouching is necessary, it is more expeditiously done by spray painting. In addition to these two ways of touch-up painting, spray cans were also tested to ascertain their desirability. Figure 12 shows aerosol spray cans of camouflage paint used for retouch painting. Figure 10 shows a soldier cleaning and preparing a scraped paint surface before retouch painting, and Fig. 11 shows him in the process of painting with an aerosol can. This method is convenient and very effective, especially for small areas. However, spray cans of paint are very expensive in comparison to bulk paint. Under normal temperatures of 60^{o} to 80^{o}F, spray cans are relatively efficient; but, as the temperature drops, they become less and less efficient and more expensive because so much paint is wasted due to pressure problems. Based on our experience, we believe that brush painting is the most efficient and effective for small areas, that spray painting is most practical for large areas, and, lastly, that spray can painting is efficient for small areas only at normal temperatures. We also feel that because of the nature of retouch painting, it can be done most effectively at the troop level as part of the unit maintenance program. The following chart shows the desirable painting locations and/or levels:

New Vehicles	Vehicles in Depot	Installation (Not Assigned)
(1) Factory (industry) (2) Depot (3) Installation	(1) Depot (2) Installation (3) Troops	(1) Installation Maintenance (2) Troops
Vehicles with Troops	**Climatic/Geographic Change**	**Retouch Painting**
(1) Installation (when time permits) (2) Troops	(1) Troops	(Troops)

e. **Painting for Seasonal or Geographic Color Changes.** The methods applicable to color changes necessary for seasonal or geographical locations are the same as for touch-up painting—brush, spray gun, or aerosol spray can. Trials at Fort Hood indicated that it took two soldiers an average of 70 minutes to convert each vehicle using spray-paint equipment. Although brush painting is feasible and practical, it is less economical and more time-consuming per vehicle than spray painting. Spraying with aerosol cans can be done rapidly; but, based on the cost of spray cans of paint, temperature problems, and waste, it is not economical or practical. We, therefore, believe that, where possible, spray painting either in the motor pool or with portable spray equipment should be used to convert the vehicles for seasonal or geographical changes; and that brush painting may be used as an alternative, especially where each vehicle's crew must repaint its own vehicle in a rapid crash conversion. Aerosol spray cans do have inviting characteristics under normal temperatures and facilitate quick conversions; however, cost and availability relegate this method to the least desirable of the three alternatives.

11. **Paint (Enamel) for Vehicles.**

a. **Description.** The paint (enamel) for the vehicles was selected to be compatible with the coating initially put on the vehicle at the factory. It is a fast-drying, dull (lusterless), high-quality enamel and may be obtained in the basic camouflage colors: light green, dark green, forest green, sand, desert sand, field drab, earth yellow, earth brown, olive drab, black, and white. The paint was manufactured under Specification TT-E-527 and the colors were specified under Specification MIL-C-595. The paint may be applied by spray gun or brush (roller application is not recommended). The painter must make sure that the newly painted surface appears wet upon application to insure good adhesion and coverage. The paint may be applied to any metal surface. When the paint is applied to a new metal surface, a wash primer (Specification MIL-P-328) is recommended to prepare the surface.

b. **Enamel Mixing.**

(1) Temperature and humidity will require adjustment of the paint to thinner ratios:

(a) 30^{O} to 60^{O} – 3 gallons paint to 1 gallon Xylene*

(b) 60^{O} to 80^{O} – 2 gallons paint to 1 gallon Xylene

(c) Above 80^{O}, relative humidity 55% – 2 gallons paint to 1 gallon Xylene and 1 pint Butyl Cellosolve**

(d) If raining or if temperature is above 80^{O} – 2 gallons paint to 1 gallon Xylene and 1 quart Butyl Cellosolve.

(2) Paint drying time over a previously painted substrata at 75^{O} is approximately 50% dry to the touch in 30 minutes and is dependent on both temperature and humidity. A new draft specification, TT-E-527, which includes the proper camouflage gloss and visual and IR reflectance is inclosed as Appendix V. Although paint is manufactured under the old Specification TT-E-527 in a number of colors, it is not stocked in the appropriate camouflage colors. The old specification uses standard Fed. Std. 595 for visual color and has no specific infrared requirement; consequently, it is not suitable for modern camouflage use. To obtain the appropriate camouflage colors and infrared reflectance for the MASSTER evaluations, special addendums were added to the existing specification and a special procurement document was made.

12. **Lacquer for Helicopters.**

a. **Description.** The lacquer used to pattern helicopters is a high-quality acrylic nitrocellulose lacquer (MIL-L-19538C, Lacquer–Acrylic Nitrocellulose Camouflage for Aircraft Use, Lusterless) and is the same as that prescribed for the initial painting of helicopters. It was prepared in the essential camouflage colors according to Fed. Std. 595.

b. **Lacquer Mixing.** Temperature and humidity will require adjustment of the lacquer mix. The normal mix is 1 gallon of lacquer to 3 quarts of thinner (cellulose nitrate). In unusually hot temperatures, 80^{O} or more, about 1 pint of Cellulose-Nitrate-Dope (Specification MIL-T-6093A, Thinner, Cellulose-Nitrate-Dope, Blush

*Xylene (Xylol).

**Butyl Cellosolve (Ethylene Glycol Mono Butyl Ether), FSN 6810-281-2001.

Retarding, Federal Stock Number 8010-162-5289) is added. In very rainy weather, it may be neeessary to discontinue painting.

The dull coating produced by the lusterless lacquer may be further modified by the use of walnut pellets to create a diffuse surface (non-glare). The mix is 1 pound of walnut pellets to 1 gallon of unmixed lacquer (or 2 gallons, 1 pint after the lacquer is mixed). This mix was used on the hub and rotor blades and other surfaces where a highly diffuse finish was necessary.

Lacquer specified under Specification MIL-L-19538C is listed in the Federal Stock Catalogue under FSC 8010; however, it is not stocked in all of the appropriate camouflage colors. Specification MIL-L-19538C uses Fed. Std. 595 for visual color and has no specified infrared reflectance. In order to obtain the appropriate camouflage color and infrared reflectance, special provisions were added to Specification MIL-L-19538C in the procurement document. A new draft specification with these special requirements is currently being prepared.

Figures 21, 22 and 23 show helicopters as they were painted for the MASSTER Phase I evaluation.

13. **Tarps and Covers.**

a. **Cotton Duck (Canvas) Tarps.** No official paint is available for this material. Both enamel and lacquer dry to a high sheen on such fabrics, make the fabric stiff and brittle, and crack and peel off readily. In order to overcome this problem, we adopted a canvas impregnant/preservative and modified it by adding pigments in the appropriate camouflage colors. This impregnant dries to a flexible consistency (stays soft) similar in feel to paraffin. The surface of the cloth should not be completely filled (flooded), and care must be taken to maintain the rough texture of the fabric. Although it produced satisfactory results, the coating increased the weight of the tarps beyond that which we deemed desirable; also, it was more diffieult to apply than ordinary coatings. Although we believe this paint system can be used effectively, we have continued to work on the compound to overcome its shortcomings. A new draft specification for use on cotton duck tarps is being written.

b. **Neoprene-Coated Tarps and Covers.** No official paint is available for this purpose. We used the same enamel as was applied to the metal, but lacquer retardant was added to insure adhesions and flexibility without cracking and peeling. This system proved easy to handle and produced surfaces nearly equal to the metal surfaces in color and gloss. The same proportions of enamel and thinner were used (2 to 1 mix) except that the thinner contained ½ pint of lacquer retardant per gallon of thinner.

The addition of the lacquer retardant increases the drying time and allows the paint to achieve a stronger bond with the neoprene coating.

14. Textured Paints. Two types of textured (anti-glare) paints were evaluated. One utilized a silica granule; the other used a walnut shell pellet which is commercially available.

a. Silica Granule-Filled. Silica granule-filled paint was provided as an anti-glare paint for rotor hubs and blades of helicopters. This paint provided a rough surface which reduced glare considerably but not completely. The paint was difficult to apply in two respects: (1) The particle was extremely heavy and required constant agitation to keep it in suspension; (2) partially because of weight and partially because of abrasion on spray gun parts, the paint was extremely difficult to spray evenly with well-dispersed granules. This paint is suitable for application only in a professional paint shop employing highly trained painters and equipped with specialized spray equipment. Several experiments with this paint showed that it was impractical for rotor blades because the weight of the coating on a surface could not be accurately controlled and consequently created an imbalance in the blade. We do not recommend this silica-filled coating for use either by industry, depots, or troops.

b. **Walnut Pellets.** Walnut pellets mixed into either lacquer or enamel (1 pound per gallon of paint) produced an even surface texture and was much easier to handle than the silica type. The weight of the pellets was considerably lighter and consequently the pellets stayed in suspension better. No difficulty was experienced in spraying evenly textured surfaces. Experiments in the aircraft paint shop at Fort Hood indicated that this coating could be applied to rotors and rotor blades without detrimental imbalancing effects. However, no paint coating should be applied to rotor blades except by experienced painters. The weathering characteristics over 1 year indicate excellent paint and texture durability using this mixture.

15. CBR Coatings (Polyurethane Coatings). As indicated in Paragraphs 11 and 12, the camouflage paint investigation dealt primarily with those paints currently in use and specified for general application to vehicles and aircraft. If the CBR threat is considered significant, however, current camouflage coatings will not be satisfactory. CBR resistance can be readily added to camouflage coatings by reformulation of the coatings without hindering their camouflage effectiveness. Research has shown that polyurethane coatings can be effectively used as CBR-resistant camouflage coatings and can be applied over the current alkyd paints. Polyurethane coatings are two-part systems with a 2 or 3 year shelf life; once mixed, however, the paint has a pot life of about 8 hours. This characteristic is no deterrent to application of the paint at the factory or depot level but would influence its acceptability at the troop level (company, battalion, or brigade). Our experience with enamels and lacquers indicates that the

amount of training and supervision necessary for polyurethane painting programs at the troop level would be greatly increased. Also, to insure continued CBR decontamination characteristics, the vehicle painted with polyurethane coatings would require repainting or touch-up with the same paint. Enamels and other paints should not be applied over this coating because they destroy the decontamination qualities of the polyurethane.

No CBR-resistant camouflage coatings have been purchased. The cost of polyurethane coatings is approximately double to triple that of current alkyd finishes. A doubling of the paint price would increase the total cost of pattern painting an M60 tank by approximately 6 percent.

16. Paint, Temporary, Lusterless, Gasoline Removable. This paint was designed as a temporary paint which is easy to apply and remove in the field. It is particularly useful in the temperate zone where snow conditions are transitory. The vehicle can be totally or partially painted white; and, then, as the snow melts, all or part of the paint can be removed with gasoline. The paint is standard and was not tested at Fort Hood, but previous work at MERDC confirms its value, especially in the above mentioned snow conditions. The paint may be applied with spray equipment or by brush. Since this is a temporary field paint, the vehicle's surface does not have to be cleaned; however, cleaning will result in a better job.

17. Vehicle Markings. White vehicle markings (stars, unit identification, and instruction signs) are highly conspicuous under all visibility conditions in the field. They are the antithesis of camouflage. The removal of these markings made a significant contribution toward reducing the threshold of visibility and enhanced the ability to conceal the vehicle. Appendix III contains a letter dated 19 Oct 72 from HQ, 2d Bde, 2AD, for distribution (units of 2d Bde), subject: "Vehicular Marking – Camouflage Vehicles," which provides instructions to the units on the allowable markings. No additional markings were applied unless absolutely essential to safety (such as high voltage) or unique vehicle operation. All markings were applied in subdued colors. It was the attitude of all concerned that administrative markings (speed, tire pressure, safe driving, no smoking) were not essential and that training and discipline could and should supplant them. MASSTER concluded in its report (see Appendix II) that "Eliminating, or painting in lusterless black, the star and administrative markings on the vehicle is the most important factor in reducing its visibility."

The reduction or elimination of the star and administrative markings, in addition to enhancing camouflage, will reduce the need for plastic stick-on stars and letters and stencils used for this purpose. It will also reduce the man-hours required for restenciling markings or for applying initial markings at the factory.

18. **Vehicle Painting (Location and Cost).**

a. **Painting Capability.** From work done at MASSTER, it is obvious that painting capability is required at four levels: (1) troop unit, (2) installation maintenance shops, (3) depot (for vehicles already in the inventory), and (4) industry for new vehicles.

(1) Troop Unit. The work accomplished at Fort Hood shows that painting at the unit level (company or battalion) is certainly feasible if the essential material, equipment, and a covered work space are available. The quality of the coatings varied considerably, depending on level of training and supervision; however, the overall quality of the coatings was better than expected, and the appearance of the vehicles was excellent. The greatest success was obtained where a team of soldiers (four to six enlisted and one NCO) was assigned the task and committed to the job until completed. Soldiers can paint their vehicles efficiently when time and equipment are available or where a large unit wants to convert for changing seasons or geographical areas in the minimum of time. The average time and paint required to paint vehicles of various types, based on that actual required at Fort Hood, are shown in Fig. 3(A) of MASSTER Evaluation (Extract), Appendix II. It must be expected that the first two to five vehicles will take as much as double the time shown in the table.

(2) Installation Maintenance Shop. The painting of vehicles at this level has several advantages:

(a) Civilian or more permanent soldier detail could be maintained

(b) Painters will have greater skill because they can be dedicated to the task

(c) Uniformly better paint job

(d) Less time and paint per vehicle for a quality job

(e) Better control of materials and equipment

The main disadvantage to painting all vehicles at this level is the elapsed time (calendar days) it would take to paint a unit. However, replacement vehicles and vehicles being repaired may be painted or repainted in the shop more efficiently than by the using unit.

The costs in man-hours and materials will be slightly less than those obtained as the averages for troop applications. The overall cost may be slightly reduced by the use of more skilled painters and more efficient equipment to prepare the vehicle for painting.

(3) Depot. Vehicles in depot can be painted more efficiently in the Depot Maintenance Shop. The painting of vehicles in depot stock by the depot maintenance shop will result in a high quality paint coating. Skilled painters and technically adequate facilities and equipment will also contribute to a more professional end product. The pattern painting of vehicles in depot stock should be made a responsibility of the depot and be done prior to issue.

One cost of camouflage (dull) pattern paint over the already painted vehicle will provide an adequate coating to impart camouflage qualities. The cost in man-hours will be slightly less in depot than the averages for troop application. The overall cost will be slightly reduced because skilled painters and more efficient equipment and facilities will be used to prepare and paint the vehicles.

(4) Industry. If pattern painting of vehicles becomes the policy of the U.S. Army for all new combat vehicles and equipment, strong consideration should be given to painting them in the factory. The new vehicle should be primed and painted with one coat of a highly durable protective semigloss and then painted with a second coat of dull (non-gloss) camouflage pattern paint (see paragraph c below). Such a system would give good protection to the metal surfaces and also provide a high quality camouflage coating. The application of camouflage patterns by industry will eliminate the need for depot painting except for reconditioned or rebuilt equipment.

b. Vehicle Painting Location/Level. The following chart shows the location at which the camouflage pattern painting of vehicles will be most economical or practical, with the most practical listed first followed in turn by those less desirable:

New Vehicles	Vehicles in Depot	Installation (Not Assigned)
(1) Factory (industry)	(1) Depot	(1) Installation Maintenance
(2) Depot	(2) Installation	(2) Troops
(3) Installation	(3) Troops	
Vehicles with Troops	**Climatic/Geographic Change**	**Retouch Painting**
(1) Installation (when time permits)	(1) Troops	(Troops)
(2) Troops		

c. **New Vehicle Painting Estimated Cost at Factory.** The following estimated costs for pattern painting are for new vehicles at the factory using production techniques and equipment. The cost breakdown is shown to provide a guide for Government estimates. Since no unique equipment is required to perform pattern painting, the facility (paint booths, compressed air, painting equipment) was assumed to exist in all factories building new vehicles. We believe the same cost differences will apply to vehicles and aircraft as indicated in the estimates shown for the M60 tank and the AH 1G helicopter. Each vehicle estimate will contain the costs for four painting systems: (a) primer coat and two coats of semi-gloss OD, the current procedure; (b) primer coat and one coat of semi-gloss OD and one coat lusterless forest green; (c) primer coat and one coat semi-gloss OD and one coat camouflage pattern paint, lusterless, in four colors [forest green (FG), field drab (FD), sand (S), and black (B)]; and (d) primer coat and two coats camouflage pattern paint, lusterless, in four colors. The cost for schemes (b), (c), and (d) is compared with scheme (a) and the percentage cost difference is shown after the estimate of each scheme.

(1) **Ground Vehicles (M60 Tank).**

(a) Primer coat and 1 coats semi-gloss OD enamel (current standard system):

2½ gal primer ($3.00/gal)	$ 7.50	
5 man-hours (mh) x $15.00 with overhead (w/oh)	75.00	
profit (10%)	8.25	
PRIMER COAT		$ 90.75
2½ gal semi-gloss OD, mixed ($3.60/gal)	9.00	
5 mh x $15.00 w/oh	75.00	
profit (10%)	8.40	
1st COAT, OD ENAMEL		92.40
2nd COAT, OD ENAMEL (same as 1st coat)		92.40
SUBTOTAL		275.55
CONTINGENCIES (5%)		13.78
TOTAL (a)		$289.33

(b) Primer coat, 1 coat OD semi-gloss enamel, and 1 coat FG lusterless enamel:

PRIMER COAT (same as in System (a))		90.75
1st COAT, OD ENAMEL (same as in System (a))		92.40
2½ gal FG lusterless, mixed ($5.00/gal)	$ 12.50	
5 mh x $15.00 w/oh	75.00	

profit (10%)	8.75	
2nd COAT, FG LUSTERLESS		96.25
SUBTOTAL		279.40
CONTINGENCIES (5%)		13.97
TOTAL (b)		$293.37

$$\text{Cost Difference} = \frac{(\text{TOTAL (b)} - \text{TOTAL (a)})}{\text{TOTAL (a)}} = 1.40\%$$

(c) Primer coat, 1 coat OD semi-gloss, and 1 coat camouflage pattern paint, 4 colors, lusterless enamel:

PRIMER COAT (same as in System (a))		$ 90.75
1st COAT, OD SEMI-GLOSS (same as in System (a))		92.40
1-1/3 gal FG lusterless, mixed ($5.00/gal)	$ 6.66	
1-2/3 gal B/FD/S lusterless, mixed	8.33	
2 mh pattern application x $15.00 w/oh	30.00	
7 mh pattern painting x $15.00 w/oh	105.00	
profit (10%)	15.00	
2nd COAT, PATTERN PAINT (4 colors)		164.99
SUBTOTAL		348.14
CONTINGENCIES (5%)		17.41
TOTAL (c)		$365.55

$$\text{Cost Difference} = \frac{(\text{TOTAL (c)} - \text{TOTAL (a)})}{\text{TOTAL (a)}} = 26.34\%$$

(d) Primer coat and 2 coats camouflage pattern paint, 4 colors, lusterless enamel:

PRIMER COAT (same as in System (a))		$ 90.75
1st COAT, PATTERN PAINT, 4 COLORS (same as in System (c))		164.99
1-1/3 gal FG lusterless, mixed ($5.00/gal)	$ 6.66	
1-2/3 gal B/FD/S lusterless, mixed	8.33	
7 mh pattern painting x $15.00 w/oh	105.00	
profit (10%)	12.00	
2nd COAT, PATTERN PAINT		131.99
SUBTOTAL		387.73
CONTINGENCIES (5%)		19.39
TOTAL (d)		$407.12

$$\text{Cost Difference} = \frac{(\text{TOTAL (d)} - \text{TOTAL (a)})}{\text{TOTAL (a)}} = 40.71\%$$

Each alternative paint system is discussed below in terms of cost, protective coating qualities, and camouflage value. In each case, the primer coat is essential on new metal surfaces to insure adequate adhesion of the paint. The procedure of using a primer first should be followed no matter which finishing system may eventually be selected.

System (a). Primer coat and 2 coats of OD semi-gloss enamel (TT-E-529): This system is now standard for all vehicles. It forms an excellent protective coating and is the least expensive of the several systems. However, it is the least satisfactory from a camouflage point of view and also presents problems in appearance when re-touch painted.

System (b). Primer coat, one coat OD semi-gloss (TT-E-485), and one coat lusterless FG enamel (this semi-gloss first coat provides a better protective coat on the vehicle and is recommended for that reason): The lusterless coating, because of its high pigment content, is slightly less durable; and, although it has good protective qualities, it is not as good as those imparted by the semi-gloss coating. The lusterless FG coating, however, provides one of the primary colors for pattern painting; and, consequently, only field drab (the other primary color), black, and sand will have to be painted at the depot, installation, or troop level. Under cases of extreme economy, this system warrants serious consideration because it provides a lusterless vehicle which can be pattern painted with a minimum of work after delivery to depot, installation, or troop levels if equipment and facilities are available.

System (c). Primer coat, one coat OD semi-gloss (TT-E-485), and one coat camouflage pattern paint, enamel (see Appendix V): Again, the semi-gloss coating is recommended for its protective characteristics; and, in addition, it provides a dark-colored base coat. Consequently, skins and abrasions of the top coating will not be as readily noticeable and retouch painting will be reduced to a minimum. By adding the one coating of camouflage pattern paint, the vehicle will be delivered to the Army in battle dress and ready for issue as a camouflage-painted vehicle. This system will relieve the depots, installations, or troops of the task of painting the vehicle except for painting necessary to maintain the appearance and protective characteristics. This system is the most inexpensive of the two systems in which vehicles may be pattern painted in the factory and 26% more expensive than the now standard two coats of OD.

System (d). Primer coat and 2 coats of camouflage pattern paint (4 colors) in lusterless enamel (see Appendix V): This system presents no advantages

over System (c) and has several disadvantages that make it a poor candidate for selection. It does not have the protective semi-gloss as a base and requires more time and, thus, more money to apply the second four-color coat. The two-camouflage-coat system will cost approximately 41% more than the standard, two-coat, OD system and 11% more than System (c).

From this analysis, the four systems rank in the following order of preference with a combined consideration of camouflage, protective coating, and cost:

1st choice, System (c)	Primer coat + one coat semi-gloss + one coat pattern paint	126%
2nd choice, System (b)	Primer coat + one coat semi-gloss + one coat FG lusterless	101%
3rd choice, System (a)	Primer coat + two coats semi-gloss OD	100%
4th choice, System (d)	Primer coat + two coats pattern paint	141%

(2) Helicopters (AH 1G).

(a) Primer coat and 2 coats semi-gloss OD lacquer (current standard system):

3 gal primer ($4.00/gal)	$ 12.00	
15 mh to mask and prime x $15.00 w/oh	225.00	
profit (10%)	23.70	
PRIMER COAT		$260.70
3 gal semi-gloss, mixed ($3.30/gal)	9.90	
10 mh x $15 w/oh	150.00	
profit (10%)	16.00	
1st COAT, LACQUER		175.90
2nd COAT, LACQUER (same as 1st coat)		175.90
SUBTOTAL		612.50
CONTINGENCIES (5%)		30.62
TOTAL (a)		$643.12

(b) Primer coat, 1 coat OD semi-gloss lacquer, and 1 coat FG lusterless lacquer:

PRIMER COAT (same as in System (a))	$260.70

1st COAT, OD LACQUER (same as in System (a))		175.90
3 gal FG lusterless, mixed ($5.60/gal)	$ 16.80	
10 mh x $15.00 w/oh	150.00	
profit (10%)	16.68	
2nd COAT, FG LUSTERLESS		183.48
SUBTOTAL		620.08
CONTINGENCIES (5%)		31.00
TOTAL (b)		$651.08

$$\text{Cost Difference} = \frac{(\text{TOTAL (b)} - \text{TOTAL (a)})}{\text{TOTAL (a)}} = 1.24\%$$

(c) Primer coat, 1 coat OD semi-gloss lacquer, and 1 coat pattern paint, 4 colors, lusterless lacquer:

PRIMER COAT (same as in System (a))		$260.70
1st COAT, OD LACQUER (same as in System (a))		175.90
1½ gal FG lusterless, mixed ($5.60/gal)	$ 8.40	
1-2/3 gal B/FD/S lusterless, mixed	9.33	
4 mh pattern application x $15.00 w/oh	60.00	
16 mh pattern painting x $15.00 w/oh	240.00	
profit (10%)	31.77	
2nd COAT, PATTERN PAINT (4 COLORS)		349.50
SUBTOTAL		786.10
CONTINGENCIES (5%)		39.30
TOTAL (c)		$825.40

$$\text{Cost Difference} = \frac{(\text{TOTAL (c)} - \text{TOTAL (a)})}{\text{TOTAL (a)}} = 28.34\%$$

(d) Primer coat and 2 coats camouflage pattern paint, 4 colors, lusterless lacquer:

PRIMER COAT (same as in System (a)		$260.70
1st COAT, PATTERN PAINT (4 COLORS) (same as in System (c))		349.50
1½ gal FG lusterless, mixed ($5.60/gal)	$ 8.40	
1-2/3 gal B/FD/S lusterless, mixed	9.33	
16 mh pattern painting x $15.00 w/oh	240.00	
profit (10%)	25.77	
2nd COAT, PATTERN PAINT		283.50
SUBTOTAL		893.70

CONTINGENCIES (5%)	44.68
TOTAL (d)	$938.38

$$\text{Cost Difference} = \frac{(\text{TOTAL (d)} - \text{TOTAL (a)})}{\text{TOTAL (a)}} = 45.91\%$$

The analysis of the various paint systems for helicopters considering cost, protective coating qualities, and camouflage value is analogous to that for ground vehicles. In each case, the primer coat is essential on new metal surfaces to insure adhesion of the paint. The procedure of priming the surface should be flollowed no matter which system may eventually be selected.

System (a). Primer coat and 2 coats of OD semi-gloss lacquer: This system is now standard on helicopters. It forms an excellent protective coating and is the least costly of the several systems; however, it is the least desirable from a camouflage point of view.

System (b). Primer coat, 1 coat OD semi-gloss lacquer, and 1 coat lusterless FG lacquer: The semi-gloss first coat provides a better protective coating and is a better first coat for that reason. The lusterless coating, because of its high pigment content, is slightly less desirable; and, although it has good protective qualities, it is not up to those imparted by the semi-gloss coating. The lusterless FG coating provides one of the primary colors of the pattern painting. Consequently, only field drab (the other primary color), black, and sand will have to be painted at the depot, installation, or troop level. Under cases of extreme economy, this system deserves serious consideration because it provides a lusterless vehicle which can be pattern painted with a minimum of work after delivery to depot, installation, or troop level if facilities and equipment are available.

System (c). Primer coat, 1 coat OD semi-gloss lacquer, and 1 coat of pattern paint lusterless lacquer: Again, the semi-gloss coating is recommended for its protective qualities. In addition, it provides a dark color as a base coat under the pattern painting. Consequently, skins and abrasions will not be readily apparent. With the addition of one coating of pattern paint, the helicopter will be delivered to the Army in battle dress and ready for issue as a camouflage-patterned vehicle. This system will relieve the depots and installations of the task of painting the vehicle except for painting necessary to maintain appearance and protective characteristics. This system is the least expensive of the two systems in which helicopters may be pattern painted in the factory and 28% more costly than the standard two-coat OD system.

System (d). Primer coat and 2 coats of camouflage pattern paint (4 colors), lusterless lacquer: This system presents no advantages over System (c) and has

several disadvantages that make it a poor candidate for consideration. It does not have the protective semi-gloss as a base and requires more time and, thus, more money to apply the second four-color coat.

The 2-camouflage-coat system will cost 48% more than the standard, OD, 2-coat system and 14% more than System (c).

From this analysis, the four systems rank in the following order of preference with a combined consideration of camouflage, protective coating, and cost:

1st Choice, System (c)	Primer coat + 1 coat OD semi-gloss + 1 coat pattern paint lusterless lacquer	128%
2nd Choice, System (b)	Primer coat + 1 coat OD semi-gloss + 1 coat FG lusterless lacquer	101%
3rd Choice, System (a)	Primer coat + 2 coats OD semi-gloss lacquer	100%
4th Choice, System (d)	Primer coat + 2 coats pattern paint	146%

19. **Durability and Appearance.**

a. **Durability.** Durability is a misleading term when describing the field service life of a paint coating. The theoretical durability (life) of the paint (2 to 3 years for enamel) is not observed under field service conditions. Such things as type of vehicle, abuses (abrasion and wear), to which the surface is subjected and type of exposure are a few conditions which influence the field life and appearance of coatings. As an example, even the most durable paint will not withstand, for more than a few weeks, the abrasion created by a tank tread throwing dirt and grit against the belly of the tank. In discussions, tank commanders in the 2d Bde indicated that their tanks are being constantly retouched or repainted to cover scraped and damaged paint surfaces. Most of the tanks in service 6 or more months showed extensive retouching, some to the point where almost the whole vehicle had been covered by retouch paint. Contrary to recommended practice, the troops used any kind of paint available to retouch their vehicles and maintain some semblance of acceptable appearance. We found that all kinds of paint from interior latex to lacquer were used to cover abrasions and worn areas. These paints cause problems in repainting and also contribute to the maintenance problem and general deterioration of appearance. This practice is attributable to the non-availability of the appropriate enamel paints at unit level.

b. **Appearance.** Retouch painting on a solid-colored vehicle creates an unsightly, mottled appearance because even separately mixed paints of the same

specification will vary in color. Painting a vehicle with these slight color mismatches of the same paint creates a mottling of the surface because of the weathering (bleaching) of the original coating and because of the technical and economic impossibility of controlling color matching to such an extreme. Therefore, the different applications in juxtaposition create the appearance of an unkempt, poorly maintained vehicle. The very nature of pattern painting contributes toward minimizing the effects of color mismatch caused by retouch (repair) painting. The contrast of the colors used in pattern painting and the smaller color areas help make retouch painting easier and reduce the conspicuousness between old and new paint. The MASSTER Evaluation (Extract), Appendix II, concludes that "pattern paint schemes reduce the need for spot painting and repainting when it is required."

20. Foreign Pattern Painting. We have received a variety of information on foreign, pattern-painting experiments and use. Both the Australians and the Swedes have conducted tests comparing patterned and unpatterned vehicles. The Australians, using slides of painted models and recognizability as their testing criterion, found that pattern painting significantly reduced the rate of vehicle recognition at all angles of view and all lighting conditions. The Swedish tests showed that pattern painting decreased detection range and increased search time for static targets and also increased acquisition time for moving targets. (Details of these tests have been excluded here because they are classified.) The official British view is that pattern painting cannot be economically justified by the results. In spite of this, however, the British Army has relented, after pressure from the regimental staffs on grounds of troop morale, and vehicles are being patterned. The British pattern, similar to the one used by the Australians in Vietnam, contains two colors, NATO green and black, selected to blend with their local terrain. The British, as well as the Swedes and Australians, use camouflage paint with low gloss and with IR reflectances comparable to those of nature when photographed with Camouflage Detection (CD) film. We have also recently learned that the German Army has issued a report based on 4 years of testing which concludes that pattern painting significantly decreases detection range.

21. Consideration of Computer-Aided Design. A combination of computer techniques—combinatorial geometry and pattern application by projection—was suggested to us and subsequently investigated as a possible tool in vehicle disruptive pattern design. With combinatorial geometry, a complex structure can be generated in three dimensions through intersection and enlargement or reduction of a library of simple geometric solids. This process, although extremely time-consuming, would be used to form a vehicle in memory for subsequent pattern application. Using methods of projection analogous to those in cartography, a continuous pattern could then be applied to the entire vehicle surface. The vehicle model is inclosed by some basic solid, most likely a sphere, on which a pattern has been drawn. Light rays from a diffuse source are projected through the sphere to the vehicle's surface delineating the pattern on the

vehicle. While this method is plausible in theory, it has several major drawbacks; the pattern will be distorted erratically because of the irregular shape of the vehicle relative to the sphere; also, the pattern shape and location are plotted without regard to the vehicle's signature cues, thus eliminating an important function of pattern painting – apparent shape distortion through deliberate coloration.

The principal failure of this process, however, is the computer's inability to analyze the vehicle's characteristics relating to internal and external patterns from the subjective, human point of view which is inherent in soldier/sensor perception. Also, the technique is incapable of choosing a pattern scale and configuration which will have apparent depth and detail at close-observation range but will coalesce to form larger color areas necessary for effective contrast reduction at long ranges.

22. Discussion of the 10 Objectives.

The MASSTER/MERDC pattern was designed to incorporate the 10 characteristics contained in Paragraph 4, Design Considerations for Pattern Painting. Although Fort Hood was the location of the evaluation, the colors and patterns were designed to be of low contrast with a variety of fall and winter surroundings and not specifically for Fort Hood. As explained in the concept of pattern painting, it is not a precise science but an art in large part. Consequently, many of the considerations in designing the pattern to meet the 10 characteristics are based on subjective evaluation and past experience with the camouflage technique. Each of the 10 characteristics selected as one objective is discussed below. That portion of the MASSTER Camouflage Evaluation, Phase I, dealing with pattern painting has been extracted and is included in this report to show their results of the evaluation (Appendix H).

a. **Develop a pattern with maximum effectiveness from ground and air observation in the target acquisition role.** This problem deals mainly with the human perception of a rifleman, gunner, or pilot and, consequently, is purely a subjective process which requires a reaction in real time. It also involves such factors as distance, angle of observation, sun angle, visual thresholds, terrain clutter, color, texture, shape contrasts, movement, and mission. It is obvious that consideration of so many variables would require compromises in order to design a pattern which presents a low contrast under a large number of circumstances. To achieve the goals of the MASSTER/MERDC camouflage program, the disruptive pattern had to be of low contrast and compatible with (not necessarily identical to) the pattern (clutter) of the surrounds in shape, color and color contrast, gloss, and apparent shadow characteristics when viewed at close range to about 800 meters. Also, the color shapes in the pattern had to coalesce into a mottled, low-contrast (single color) target at greater (beyond 600-800 meters) distances where the human perception system causes small detail to coalesce into larger masses. Objects on the terrain also behave in the same way and, consequently,

the coalescence is consistent with the natural environment. Contrasts between the separate colors in the pattern (mainly brightness) is essential to resolution of the pattern. However, if the contrast is too great, the target will be highly conspicuous at close range (150-200 meters) and blend (coalesce) to a contrasting (conspicuous) color at distances of 800 meters or greater. The effectiveness of very contrasing patterns will depend entirely on the contrasts within the surrounds; but, except for highly selected circumstances, such strong contrasts will make the target conspicuous at all ranges. The design for MASSTER was, therefore, made to have a good contrast at up to about 800 meters and to blend into a mottled, non-contrasting color at greater distances.

The questioning of tankers, infantrymen, and pilots in the field indicated that this objective was satisfied under field conditions in battalion tests and ACCB III. It was the general consensus of the individuals questioned that:

(1) The pattern-painted vehicles were much more difficult to detect than non-pattern-painted vehicles.

(2) Once visual contact was broken, several seconds were required to relocate the target.

(3) Detection of the number of vehicles in a formation was more difficult and required search for each individual one.

(4) Observation through weapons sights and range finders was more difficult.

(5) In general, most of the individuals considered the vehicles harder to detect than solid-colored vehicles.

b. **Develop a pattern which can be applied by troops with minimum training and effort using the minimum amount of special equipment (if possible, no special equipment).** Various aspects of this objective are also discussed in several previous paragraphs: Training, Vehicle Preparation, Application of the Pattern, and Vehicle Painting. Troops are capable of accomplishing the pattern painting of their vehicles after a short orientation and demonstration followed by practical work under supervision. Appendix II contains handouts used during the troop instruction period. The handouts contain the concept, paint nomenclature, mixing instructions, equipment lists, and tips. Other than supplementing each unit with extra paint spray equipment, no special equipment was required. The painting of approximately 1400 vehicles by troops from August 1972 to February 1973 in their motor pools is strong evidence that the objective was met.

c. **Develop a pattern with maximum effectiveness under combat conditions but also a pattern which presents a good military appearance in garrison.** The extract of the MASSTER Evaluation (Appendix H) expresses MASSTER's evaluation of the pattern painting from a military point of view. Previously, pattern painting was designed with only the combat mission in mind. Consequently, the vehicles were not always presentable in garrison from an aesthetic point of view. The vehicles painted at Fort Hood were used in parades and reviews, at the Texas State Fair, and also in recruiting. The soldiers feel that their pattern-painted vehicles present a desirable military appearance. Conversation with soldiers in the several battalions of the 2d Armored Division bronght forth such comments as "Now we're fighters, not lovers," "It (tank) looks big and mean," "We look like a fighting outfit now," "We're in battle dress and ready for action." In general, the soldier felt like the unit had a more professional appearance, and most of them took pride in their new image.

d. **Develop a pattern using colors from the standard camonflage chart (TM 5-200, Fig. 51) and thus avoid color mixing or tinting in the field to achieve the specific color.** The colors specified in the draft specifications are highly controlled for proper visual color and near infrared reflectance. The colors pictured in TM 5-200, Fig. 51, approximate the visual appearance of the specified colors. Ths group of 12 colors was used in formulating the color patterns for worldwide application. Color combinations using the 12 colors for the various terrain conditions were designed to reduce contrast as far as possible over a wide range of conditions. Because of the many considerations necessary, any given pattern may not be an exact match for some specific local condition. However, the 12 colors give considerable latitnde to modify the color and more closely match such a situation as the mission dictates. Table 2 shows the color designations for the various geographic and climatic areas.

e. **Design the patterns in such a way as to achieve mutnally enhancing qualities when combined with other camouflage techniques such as natural material applied in brackets.** The pattern painting was designed to have the proper coalescing characteristics and compatible color and color contrast to blend with the terrain elements. The pattern size and internal contrasts form a disruptive mottling of the image and thus provide image distortion. The addition of natural foliage or other supplemental material over this base enhances the total scheme by creating additional shadows and highlights and carrying the pattern beyond the vehicle configuration.

f. **Create a design which will permit the changing of one or two colors to accommodate seasonal and geographic changes (avoid the need to completely repaint the vehicle for such changes).** Table 2 provides the color combinations for various terrain conditions. Selection of colors for different terrain types was based on previous experience with world terrain types, on geographic studies, and on the *World Color Regions Atlas* prepared by USA Natick Laboratories in cooperation with MERDC. The

Table 2. Camouflage Pattern Painting Color Chart for Geographic and Climatic Changes

Location	Recommended Color Distribution[b] 45%	45%	5%	5%
Fort Hood, Texas (MERDC/MASSTER Pattern)	FG	FD	S	BL
Winter US & Europe – Verdant	FG	FD	S	BL
Summer US & Europe – Verdant	FG	DG	S	BL
Tropics – Verdant	FG	DG	LG	BL
Gray Desert	S	FD	EY	BL
Red Desert	ER	EY	S	BL
Winter Arctic	W	W	W	W
Snow – Temperate w/trees & shrubs[a]	FG	W	S	BL
Snow – Temperate w/open terrain[a]	W	FD	S	BL

[a]This system is for use only in areas with intermittent snow which does not completely cover the terrain thus leaving trees or patches of soil bare. The gasoline-removable paint is ideally suited to this application because it can be removed and the vehicle restored to its original colors.

[b]The following color numbers are used in Fig. 51, TM 5-200.

No.	Color Key	
1	W	White
2	DS	Desert Sand
3	S	Sand
4	EY	Earth Yellow
5	ER	Earth Red
6	FD	Field Drab
7	EB	Earth Brown
8	OD	Olive Drab
9	LG	Light Green
10	DG	Dark Green
11	FG	Forest Green
12	BL	Black

colors selected for the MASSTER Evaluation and designated on the MASSTER/MERDC, pattern-painting designs in Appendices IA and IB (separately bound) were selected to be compatible with the fall and winter terrain at Fort Hood and also for temperate winter in the US and Europe. The gray desert and red desert colors are based on experience in the American desert and, specifically, on an investigation leading to selection of test areas representative of world deserts and on the *World Color Regions Atlas*. The arctic and snow color selections are based on camouflage experience at Fort Churchill, Paradise Valley, California, Fort Belvoir, and Northern Europe in WWII. Tropical colors are based on camouflage experience and studies in Panama. Table 2 also indicates the color substitutions necessary to accommodate the vehicles to changing terrain requirements.

The color combinations are selected to reduce visibility over wide regions and are a compromise of many factors. For this reason, circumstances may arise where the colors are not an ideal match for the specific local situation. Under such circumstances, local adjustments can be made using the colors in the standard color chart (TM 5-200, Fig. 51). The colors specified for the various terrain types will provide good camouflage characteristics, low contrast, and low visibility thresholds. Supplementing these colors with natural material and discriminating use of the terrain will result in superior results. Under intermittent snow conditions, the white coloration (partial or all white) can be achieved by using temporary, gasoline-removable paints (Specification MIL-P-13983) which may be removed with gasoline by degrees or completely as the snow melts.

g. **Create a design in which the paint may be easily retouched without creating unsightly mottling or color mismatches.** The pattern-painting technique lends itself to the accomplishment of this objective because it produces a mottled, colored surface. Solid-colored vehicles are subject to unsightly mottling because of color mismatches between different batches of paint even though the paint is manufactured in accordance with the same color specification. Therefore, single-colored vehicles that are retouch-painted present a poor appearance after a short time – 6 months to 1 year. Color mismatches between batches of paint are not aesthetically objectionable on the pattern-painted surface because the color area of a single color is smaller and contrasts between adjacent colors are distinctive. Therefore, slight mismatches are not as discernible in this more complex environment.

h. **Avoid systems which require precise execution of the line and shape of the individual patterns.** The MASSTER/MERDC pattern was designed so that the contiguous color lines could vary as much as ±2 inches and still produce satisfactory appearance and disruptive qualities as long as the general proportions are maintained. The freeform shape contributes to these qualities and the flamboyance of the line contributes to variation in line displacement without producing undesirable effects. The flamboyance of the line also helps in teaching the soldiers to avoid lines that emphasize and strengthen the vertical and horizontal lines of the vehicle. The painting of vehicles at Fort Hood following the MASSTER/MERDC designs displays considerable deviation from the precise adherence to the drawing, in some instances as much as 6 inches, and yet the patterns perform their intended function.

i. **Use paints which are obtainable in the federal stock system insofar as possible and will be easy to apply, quick drying, and compatible with the original paint as a substrate.** The paints examined for use in the evaluation were: Enamel (Specification TT-E-527), the same coating used on the vehicles; Lacquer (Specification MIL-L-19538C), the same lacquer used on helicopters; Preservative Coating for Canvas (Specification TT-P-595A); Water Base Paint (Specification MIL-P-13340B); and Gasoline-Removable Paint (Specification MIL-P-13983). The enamel, lacquer, and canvas

preservative were selected because they were originally specified for the vehicles and aircraft involved. The paints were not available in the camouflage colors desired so, initially, they were bought in colors under Fed. Std. 595. Because the paints are the same as those used in the initial painting, the problem of compatibility was solved. All three coatings are quick drying, and handling problems were minimal. Although mixing of the coatings involved the addition of thinners, it did not involve unusual procedures. Consequently, a short training period and instruction sheets were adequate to acquaint the soldiers with the process.

j. **The system must lend itself to application by soldiers or by industry.** The soldiers at Fort Hood had no unique difficulties in using the system (painting and application of patterns). We anticipate no problems to be encountered by industry because they will employ skilled painters and professional equipment and painting facilities.

IV. CONCLUSIONS

23. **Conclusions.** It is concluded that:

a. Camouflage pattern painting is an effective camouflage technique which reduces visual and near infrared ground target acquisition from ground or air observations.

b. The cost of pattern painting is estimated to be 26% higher than the present finishing system for vehicles with equivalent service life.

c. If a CBR threat is considered significant, it is technically feasible to add CBR characteristics to camouflage paints at double to triple the paint cost but with only about 6% increase in total cost.

d. Our ten technical objectives have been accomplished:

(1) Develop a pattern with maximum effectiveness from ground and air observation in the target acquisition role.

(2) Develop a pattern which can be applied by troops with minimum training and effort using the minimum amount of special equipment (if possible, no special equipment).

(3) Develop a pattern with maximum effectiveness under combat conditions but also a pattern which presents a good military appearance in garrison.

(4) Develop a pattern using colors from the standard camouflage chart (TM-5-200, Fig. 51) and thus avoid color mixing or tinting in the field to achieve the specific color.

(5) Design the patterns in such a way as to achieve mutually enhancing qualities when combined with other camouflage techniques such as natural material applied in brackets.

(6) Create a design which will permit the changing of one or two colors to accommodate seasonal and geographic changes (avoid the need to completely repaint the vehicle for such changes).

(7) Create a design in which the paint may be easily retouched without creating unsightly mottling or color mismatches.

(8) Avoid systems which require precise execution of the line and shape of the individual patterns.

(9) Use paints which are obtainable in the federal stock system insofar as possible and will be easy to apply, quick drying, and compatible with the original paint as a substrate.

(10) The system must lend itself to application by soldiers or by industry.

e. For camouflage painting by industry, the most satisfactory system from the standpoint of camouflage, preservative qualities, and cost is: one coat of semi-gloss (enamel for ground vehicles and lacquer for helicopters) and one coat of lusterless pattern paint (see para 18c for the alternatives).

f. The pattern painting designs provided in Appendices IA and IB, combined with technical information and guidance, are suitable for publication in a technical bulletin or manual and for distribution to the Army.

V. ILLUSTRATIONS

Fig. 1. Pattern-painted vehicles (M113, M60, M109 How) used in demonstration of the technique, June 1972, at Fort Hood. The designs for Phase I pattern-painting evaluation were based on this demonstration.

Fig. 2. Helicopters painted at Fort Belvoir and ferried to MASSTER for demonstration. These aircraft served as the basis for designs employed in Phase I evaluations.

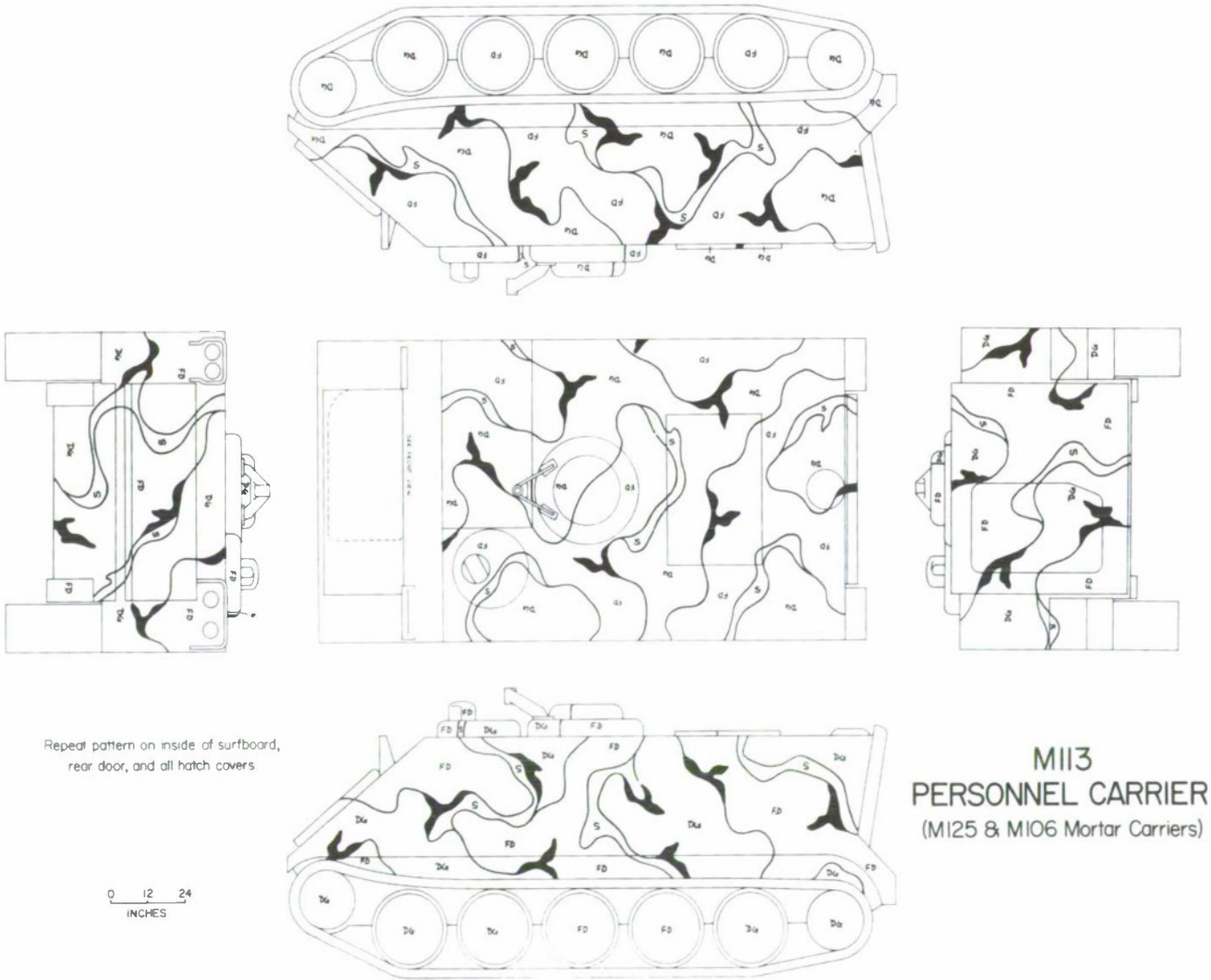

Fig. 3. Pattern-painting design for the M113 Personnel Carrier.

Fig. 4. Soldiers cleaning vehicle surfaces with detergent prior to painting.

Fig. 5. Soldier sanding off white markings prior to repainting.

Fig. 6. Soldier applying a pattern to an M577 with chalk. Note that the color is indicated in each pattern area.

Fig. 7. Soldier outlining the pattern in the color to be painted. This method provides a boundary and controls the painting within its limits.

Fig. 8. Soldier finishing a pattern-painted M113 outside of the motor pool. These final touches were made outside where defects could be detected easily.

Fig. 9. Soldiers applying the black figure with a ½-inch artist brush. When greater skill was acquired with the spray equipment, most units spray painted this figure.

Fig. 10. Soldier cleaning and preparing a scraped paint surface before retouch painting.

Fig. 11. Soldier retouch painting using an aerosol spray can of camouflage paint.

Fig. 12. Aerosol spray cans of camouflage paint used in the retouch painting evaluation.

Fig. 13. Pattern-painted M113 APC's in motor pool.

Fig. 14. Pattern-painted M109 (155 mm How) in motor pool.

Fig. 15. Pattern-painted M577 in motor pool.

Fig. 16. Pattern-painted M113 APC's in the field.

Fig. 17. Pattern-painted M60 tank in the field.

Fig. 18. A pattern-painted M577 parked in a clump of trees. Although the M577 is visible, the pattern painting makes the vehicle an indistinct target.

Fig. 19. A pattern-painted M113 parked in center trees with an M577 in left background.

Fig. 20. A bivouac area with a battalion HQ and TOC composed of four, pattern-painted M577s near center of the view.

Fig. 21. Pattern-painted UH 1 Huey as used in Phase I camouflage evaluations.

Fig. 22. Pattern-painted AH 1 Cobra as used in Phase I camouflage evaluations.

Fig. 23. Pattern-painted OH 58 Kiowa as used in the Phase I camouflage evaluations.

APPENDICES IA AND IB

CAMOUFLAGE PATTERN PAINTING DESIGN DRAWINGS

NOTE: Only the Tables of Contents for Appendices IA and IB are included here; the two complete volumes of patterns are bound separately to facilitate their use.

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APPENDIX IA

APPENDIX II

MASSTER EVALUATION (EXTRACT)

Camouflage Paint Patterns/Colors – Tactical Vehicles
Camouflage Paint Patterns/Colors – Aircraft

CAMOUFLAGE PAINT PATTERNS/COLORS – TACTICAL VEHICLES

Camouflage pattern painting reduces the detectability and recognition of tactical military vehicles and provides an excellent base for further, more-complete camouflage. In addition, the utilization of camouflage-pattern-painted vehicles has a favorable psychological impact on users. All tactical vehicles should be painted with the MASSTER/MERDC basic pattern/colors combination at the production line.

Description.

The MASSTER/MERDC basic camouflage pattern under evaluation is the result of melding different camouflage patterns which were developed for specific geographical locations, thus creating a generally all-purpose pattern. The purpose of the pattern is to disrupt the identifying features and highlights to make the vehicle more difficult to detect and identify. The disruption is accomplished by using lusterless enamel paint to reduce glare of highlights, color to reduce the contrast with the surrounding soil/vegetation and external shadows, and pattern to disrupt the geometric lines and overall configuration of the item.

A characteristic of the MASSTER/MERDC basic camouflage pattern is a capability to change one or, at most, two colors within the pattern to accommodate seasonal and geographical changes. The Basic Pattern consists of using four colors in the following percentages: 40%, 40%, 15%, 5%.

The MASSTER/MERDC basic pattern/color combination which was evaluated is as follows: forest green: 40%; field drab: 40%; sand: 15%; black: 5%. The pattern eliminates all administrative markings except the USA number and unit bumper markings which are painted in lusterless black. Detailed technical data and individual equipment drawings will be provided by a technical pattern paint report to be published by MERDC.

The metal paint used is fast-drying, dull, high-quality enamel manufactured under Specification TT-E-527 and the colors are specified under MIL-C-595. The paint may

be applied to any metal surface; but, when it is applied to an unpainted metal surface, a wash primer (MIL-P-328) is recommended. The pattern painting of canvas is accomplished using a preservative coating manufactured under Specification TT-P-595.

Methodology.

The evaluation of the effectiveness of pattern-painted tactical equipment was initiated by a detection exercise conducted in June 1972. The first step taken to reduce vehicle detectability was to eliminate the distinctive signature of the white star and white administrative markings. This was accomplished by overpainting the white markings with lusterless black paint. Next, representative vehicles (M-60, M-109, M-113, M-548) were painted with three camouflage pattern/color variations, and series of ground and aerial observations at different ranges were taken. The effectiveness of the various camouflage variations was examined, and a selection of the best scheme was made. The results of the initial exercise indicated that the removal of the white markings significantly reduced the visibility of the vehicles and that the addition of a camouflage pattern further reduced the visibility. Based on these results, a decision was made to camouflage pattern paint all vehicles in the 2d Bde, 2d Armor Division.

In July 1972, a series of classes and practical exercises were presented by the MERDC camouflage augmentation team to selected personnel from the 2d Bde, 2d Armor Division. The classes and practical exercises lasted 2 days per battalion-sized unit and included the theory of pattern painting, marking and painting techniques, safety, and care and maintenance of spray guns and other painting equipment. Practical exercises were then conducted concerning correct preparation for painting (washing, sanding, masking) pattern chalking, and spray painting. After training was completed, the camouflage pattern paint conversion of all vehicles in the 2d Bde (St Lo), 2d Armor Division, was initiated by troops in unit motor pools. Brush and spray painting were initially utilized. Brush painting, however, was discontinued because it was slower, utilized more paint than spraying, and provided a less effective pattern.

Evaluations of the effectiveness of the camouflage patterns were conducted on a minimum interference basis by MASSTER/MERDC personnel during all tactical exercises conducted by the brigade. Recommendations for pattern improvement were obtained and analyzed; and modifications to the existing pattern were accomplished.

A message, HQDA (DAFD-SDS), 212110 Sep 72, Subj: Camouflage, was received instructing MASSTER to expand the scope of camouflage paint evaluation to include solid, one-color paint schemes (Lusterless OD and NATO green). Troop labor was again used to convert vehicles to the solid, one-color paint schemes.

In addition to the continual evaluation of the camouflage-pattern-painted and solid, one-color-painted vehicles during normal training exercises, a dedicated detection exercise was conducted to evaluate these schemes. Daytime observations were conducted of the vehicles at various ranges, under varying light conditions, with varying backgrounds, from the ground and from the air. Nighttime ground observations were conducted at varying ranges utilizing night-observation devices (TVS-4, PAS-7, PVS-2). In addition, IR and photographic data was obtained from aircraft flying at 300, 1000, and 2000 feet AGL.

To gain greater insight into pattern painting, its effectiveness was evaluated by comparing various disruptive patterns containing different color combinations which had been applied to flat plywood panels. The panels were then observed at varying ranges at three different times of the day to obtain data concerning various sun angles against varying backgrounds at ranges from 300-1200 meters and observed by airborne and ground observers.

Results and Analysis.

The quality of both the pattern and the paint application produced by troops of the 2d Bde was more than adequate. In order to accomplish the painting, the units had to be augmented with paint spray guns and oil and water separators for their air compressors. No problems were encountered in applying enamel paint over existing semigloss surfaces. Spraying proved to be more effective than brush painting in that it was faster, required less paint, and produced a more effective pattern. During Phase I, approximately 1300 vehicles of all types were painted utilizing the MASSTER/MERDC basic pattern/colors.

The durability of the lusterless paints utilized was not a major factor evaluated. The paints utilized were procured under standard military specifications and, as such, a durability evaluation vis-a-vis other paints was not specifically conducted. Questionnaires and structured interviews indicated that there was no appreciable difference in durability of the evaluated paints when compared to semigloss coatings. In addition, while spot painting, the problem of matching numerous spectral variations of standard semigloss OD paints with existing surface paints was, with the applications of patterns, virtually eliminated. Spot painting on pattern-painted vehicles was not as visible as on a standard-painted vehicle. Elements of the 1st Battalion, 50 Infantry (Mech), purposely deferred spot painting for six months to evaluate the adhesiveness and eye appeal of the color schemes after numerous field exercises. The results indicated that even though at close inspection the need for spot painting was evident, at 30 meters and beyond the need was not discernible to the unaided eye.

Color conversions on the basic pattern/color evaluated to satisfy simulated geographical and seasonal changes were executed on a minimum number of selected fighting vehicles. The conversion took two men an average of 70 minutes per vehicle to accomplish. The effort and time required to convert was considered as minimal and within the capability of the unit.

The overpainting of the white star and the elimination of all administrative markings (with the exception of USA numbers and unit number markings which were also painted lusterless black) drastically reduced the ability to detect the evaluated vehicles when compared to standard-painted vehicles with white stars and administrative markings. This reduction is particularly evident to the unaided eye at ranges from 50-500 meters. The procedure of overpainting white markings with lusterless black paint was considered the biggest factor in reducing detection.

The appearances of vehicles with the solid, single-color schemes of lusterless OD and NATO green paint were rated as better than the standard paint scheme in that they did reduce glare, but they did not disrupt the features of the vehicles. The overwhelming majority of observers indicated that the MASSTER/MERDC basic pattern/colors did reduce detectability and were superior in disrupting vehicle configuration and reducing glare than the other combinations of painted vehicles evaluated. Ground and aerial observers and aerial photography did indicate that the effectiveness of the patterns and the associated detection ranges varied according to light conditions and terrain background. However, the MASSTER/MERDC basic pattern/colors was believed to be the best all-purpose scheme.

In summary, the overall effectiveness ratings given by users, commanders, and observers during direct and indirect observations were as follows:

- Standard semigloss OD with white markings – Worst.
- Standard semigloss OD with subdued markings – Big improvement over standard.
- Lusterless NATO green and world OD – Better than standard with white or subdued markings but did not disrupt features.
- MASSTER/MERDC basic camouflage pattern/colors – Best and the only scheme evaluated that aided in disrupting features.

The truck-mounted signal shelters painted with MASSTER/MERDC camouflage pattern did not experience to date any appreciable degradation of their operational capabilities. The overall effect of camouflage (pattern paints, natural foliage, drape nets) had no apparent affect on the operating temperatures of the signal shelters.

The results of the subjective evaluations (ground and aerial observations) conducted utilizing the plywood panels indicated that the comparative effectiveness of camouflage patterns/colors varied as the range, light, background, and foreground conditions of the evaluation were changed. However, the subjective order of merit under most conditions places the MASSTER/MERDC pattern/color combinations at the top or very near the top of all schemes evaluated under all conditions. The consensus indicated that the MASSTER/MERDC basic pattern/color was the most suitable when considering all conditions.

Observations conducted with the use of NOD's indicated that the solid, single-colored vehicles at a 400-meter range and less presented more intense images than the MASSTER/MERDC camouflage pattern at the same range which presented a disrupted, less-intense image. The interpretation of aerial IR imagery of all patterns evaluated indicated that all the vehicles in the imagery regardless of paint schemes were discernible as hot spots of nearly the same intensity. The consensus of all observers, unit commanders, and user indicates that the painting of military equipment with a camouflage pattern has a beneficial, but largely unquantifiable, psychological impact on all personnel. Units possessing pattern-painted vehicles were observed to be more diligent in applying sound camouflage techniques than units with standard-painted equipment. The camouflage-painted equipment induced personnel to "think camouflage." The proven inherent and psychological advantages of pattern-painted vehicles has prompted imitative efforts throughout Fort Hood by units not directly involved with the camouflage evaluation program. The imitative efforts have also leaped to other installations in CONUS, and numerous calls are received daily by MASSTER from different units requesting assistance in developing and establishing all-inclusive camouflage programs. In particular, information is requested concerning camouflage pattern painting and assistance in obtaining camouflage uniforms.

Conclusions

- Eliminating, or painting in lusterless black, the star and administrative markings on a vehicle is the most important factor in reducing its visibility.
- Camouflage pattern painting is an effective, disruptive camouflage technique at ranges up to approximately 800 meters to the unaided eye and is superior for camouflage purposes to standard semigloss OD, world OD, or NATO green.
- Camouflage painting is by itself ineffective in concealing military equipment unless the camouflage-painted item is properly sited to blend with the surrounding background.
- Utilization of pattern-painted vehicles has a psychological effect on personnel that induces them to practice sound camouflage techniques.

- The MASSTER/MERDC basic camouflage pattern/color is generally the most effective camouflage scheme when considering various conditions of range, light, background, and foreground and can be readily changed to blend with extreme conditions.
- When viewed through NOD's at ranges of 400 meters and less, camouflage patterns disrupt features and present a relatively subdued image.
- Average troops with minimal training can, in a relative short time, apply or modify a camouflage pattern to their organic equipment with a paint brush or spray gun.
- Average troops with no additional pattern paint training can, in a relative short time, modify the color of MASSTER/MERDC basic pattern to accommodate seasonal and geographical changes.
- Lusterless world OD and NATO green solid, single-color paint schemes reduce glint and glare as compared to standard semigloss OD but do not disrupt features nor aid in reducing visibility when viewed by NOD's.
- None of the paint schemes evaluated reduces thermal signatures.
- Pattern paint schemes reduce the need for spot painting and repainting entire vehicles and increase the ease and eye appeal of spot painting when it is required.
- There is no appreciable difference in durability between the lusterless enamel paints evaluated and standard semigloss paints.
- Spray painting is faster, utilizes less paint, and produces a more effective pattern than using a paint brush.

Recommendations

- That all new or rebuilt vehicles and associated OVE (thereby excluding administrative vehicles-sedans, buses, etc) be painted with the MASSTER/MERDC basic camouflage pattern/colors on the production line or in rebuild facilities.
- That tactical vehicles currently located in troop units be painted by troop labor with the MASSTER/MERDC basic pattern in the color scheme most suitable to the particular environment.
- That pattern drawings and pattern paint instructions for all tactical vehicles be included in all equipment FMs, TMs, and log books.
- That R&D effort be expedited to develop camouflage paints which counter thermal and radar sensors and provide CBR protection.

TYPE	AVERAGE* MANHOURS	AVERAGE PAINT/GALS	AVERAGE THINNER/GALS
M35	15	1.00	.50
M51	17	2.00	1.00
M60A1	30	2.16	1.10
M88	19	1.50	.75
M109HOW	15	1.00	.50
M109VAN	18	1.00	.50
M113	20	.83	.42
M125	20	.83	.42
M151	12	.50	.25
XM163	14	1.00	.50
M561	12	1.00	.50
M577	20	1.16	.58

ENAMEL PAINT – COST PER GALLON

Black	$4.39
Sand	2.95
Forest Green	7.75
Field Drab	3.96

Standard camouflage pattern being tested consists of 5% black, 15% sand, 40% field drab, and 40% forest green.

*Troop labor.

Fig. 3(A). Camouflage Pattern Painting Statistics.

CAMOUFLAGE PAINT PATTERN/COLORS – AIRCRAFT

The pattern painting of helicopters reduces the ability of observers to detect and recognize the aircraft while on the ground and while flying low level or nap-of-the-earth altitudes when viewed against certain terrain backgrounds. The pattern painting also provides an excellent base for further, more-complete camouflage while on the ground. The MASSTER/MERDC basic camouflage pattern/colors should be applied at the production line and rebuild facilities on all tactical Army aircraft.

Description.

The MASSTER/MERDC camouflage basic pattern/colors evaluated are designed to disrupt the identifying characteristics of shape, shadow, and highlights, thereby making aircraft more difficult to detect and identify. The disruption is accomplished by using lusterless lacquer paints to reduce glare, color to reduce contrast with the surrounding environment, and pattern to disrupt the geometric lines and overall configuration. The lacquer paint used is high-quality acrylic nitrocellulose lacquer manufactured under Specification MIL-L-19538C, and the camouflage colors are manufactured according to Federal Standard 595. The camouflage pattern/colors designed for aircraft were generally the same as those for ground vehicles. The rationale used in the development was basically the same, and many of the detection exercises conducted for ground vehicles were applicable to aircraft. Therefore, additional camouflage pattern/colors descriptive data and rationale is found within this report in the module entitled "Camouflage Paint Pattern/Colors – Tactical Vehicles."

Methodology.

The painting of the aircraft for the evaluation was accomplished by experienced painters from the Aircraft Maintenance Branch, DIO, Fort Hood, utilizing their organic facilities. The facilities were inadequate for production pattern painting in that environmental control equipment was lacking. The end product (paint adherence), even though satisfactory for the evaluation, was not as high a quality as would be expected from the production line or rebuild facilities. Durability of the paint, therefore, should not be considered as the best which can be achieved since it was applied in what were considered inadequate facilities.

The pattern painting of tactical helicopters was evaluated in conjunction with normal training, operations, and testing of troop units and during MASSTER Test 1029, Helicopter Disguise Evaluation. Comparative comments concerning the camouflage effectiveness of the standard OD painted fuselage versus the MASSTER/MERDC basic camouflage pattern/colors were obtained from observers viewing helicopters by air to

ground, ground to air, air to air, and ground to ground surveillance. Observations were made of the helicopters while parked against various backgrounds and while flying nap-of-the-earth, low level, and skylined, over various types of terrain. Observations were also conducted at night utilizing natural and artificial illumination. These night observations were conducted using an AN/PVS-2 while the aircraft was parked and illuminated either by moonlight or Xenon IR illumination. In addition, numerous subjective questionnaires and structured interviews were used to obtain additional data.

Paint peeling and flaking occurred on some of the evaluation aircraft. The peeling and flaking has not yet, however, deterred from the effectiveness of the pattern-paint schemes. Since the paint used is military standard paint, it is believed that the flaking and peeling is the result of the inadequate painting facilities.

During Phase I, there were 54 aircraft painted with the MASSTER/MERDC basic pattern/colors. Average labor and materiel required to paint the helicopters are listed below by type aircraft:

Type	Labor (Manhours)	Paint (Gallons)	Thinner (Gallons)
AH-1G	80	2.00	1.00
UH-1	90	2.30	1.20
OH-58	70	1.30	.60

As all detection exercises have previously illustrated, the results of the daytime observations indicated that the position of the aircraft in relation to the sun and existing shadows plays an important role in detection. When observers viewed a helicopter with the sun to the rear of the aircraft, there was no significant difference in detection between a camouflage-pattern-painted fuselage or a standard-painted fuselage since the pattern was in the shade and the basis of detection was the silhouette. When observations occurred with the sun overhead or at angles to the rear of the observer, the camouflage patterns on the fuselage were discernible and thus caused a disruptive effect which make the aircraft more difficult to detect than a standard-painted fuselage. Detection ranges varied according to light, background, and foreground conditions.

The camouflage pattern assisted in disrupting the aircraft's configuration when viewed through AN/PVS-2 under moonlight and Xenon infrared illumination.

Ground and air observers indicated that there was no significant difference in the detection of flying aircraft with various paint schemes when skylined; however, pattern-painted aircraft were more difficult to detect when viewed against certain terrain backgrounds. Limited experimentation indicated that optical tracking of pattern-painted

helicopters when flying against certain terrain backgrounds was also more difficult than tracking standard OD aircraft.

Conclusions.

- There is no discernible difference between the ability to detect camouflage-painted aircraft as compared to standard-painted aircraft when skylined.
- Camouflage patterns aid in reducing the detectability of parked aircraft when viewed against certain terrain background by the naked eye and through NOD's.
- Camouflage patterns aid in reducing the detectability of low-flying aircraft when viewed against certain terrain backgrounds.
- Limited experimentation indicates that camouflage patterns may increase the difficulty to optically track aircraft when viewed against certain terrain backgrounds.

Recommendations.

- That new or rebuilt tactical Army aircraft be painted with the MASSTER/MERDC basic camouflage pattern/colors on the production line or rebuild facilities.
- That tactical Army aircraft currently located in troop units be painted, if appropriate painting facilities are available, with the MASSTER/MERDC basic pattern in the color scheme most suitable to the particular environment.
- That pattern drawings and pattern painting instructions for all Army tactical aircraft be included in all equipment FMs, TMs, and log books.
- That R&D effort be expedited to develop camouflage paints which counter thermal and radar sensors and provide CBR protection.

APPENDIX III

LETTER HQ, 2d BRIGADE, 2 AD
SUBJECT: VEHICULAR MARKING – CAMOUFLAGE VEHICLES

DEPARTMENT OF THE ARMY
Headquarters, 2d Brigade
2d Armored Division
Fort Hood, Texas 76546

ALBAA2B-S4 19 October 1972

SUBJECT: Vehicular Marking – Camouflage Vehicles

SEE DISTRIBUTION

1. Attached letter is forwarded for information and guidance.

2. Indicated in paragraph 2 of attached letter are the markings to be placed on camouflage painted vehicles. All other markings as outlined in 2d Armored Division Regulation 746-5 will not be applied unless approved through this Headquarters.

3. A copy of this letter will be filed in each Maintenance Section.

FOR THE COMMANDER:

/s/ James R. Braun
/t/ JAMES R. BRAUN
CPT, ARMOR
Adjutant

1 Incl
as

DISTRIBUTION:
5ea CO, 1/66 Arm
5ea CO, 2/67 Arm
5ea CO, 1/50 Inf
2ea CO, HHC 2d Bde
5ea CO, 1/14 Arty
2ea CO, B2/5 ADA
2ea CO, 124 Maint, C Co
2ea CO, 502 QM
2ea CO, B Co 17 Eng
2ea CO, C Co 48 Med
2ea CO, 142 Sig
2ea CO, D Trp 2/1 Cav
2ea CO, 502 MP

DEPARTMENT OF THE ARMY
HEADQUARTERS 2D (ST LO) BRIGADE
2d Armored Division
Fort Hood, Texas 76546

ALBAA2B CO 18 October 1972

SUBJECT: Vehicular Markings – Camouflage Vehicles

Commander
2d Armored Division
ATTN: ALBAAG4
Fort Hood, Texas 76546

1. Request permission for this Brigade and supporting units whose vehicles are camouflage painted in support of the MASSTER Camouflage Evaluation Program be exempt from the normal vehicular marking requirements as required by 2d Armored Division Regulation 746-5 except as outlined in paragraph 2 below.

2. Recommend vehicular markings be limited to:

a. Registration Number: Number only, 2 inch black letters.

b. Unit Identification: Standard bumper unit identification markings, 2 inch black letters.

c. External fire extenguisher markings, "First Shot, Second Shot", Tanks Only, 1 inch black letters.

d. Maximum Speed: 1 inch black letters.

e. Other safety markings as deemed appropriate by the Commander concerned, such as "DANGER, High Voltage", 1 inch black, or contrasting camouflage color letters.

3. Stars, fill levels, or other markings to include the yellow good driver label, DA Form 76, will not be placed on camouflage painted vehicles.

4. The recommendation outlined in paragraphs 2 and 3 above have been coordinated with and have the approval of the MASSTER Camouflage Evaluation Program Project Officer. Further vehicle marking beyond that outlined in this letter will be withheld pending approval.

/s/ Garland R. McSpadden
/t/ GARLAND R. McSPADDEN
COL, Armor
Commanding

APPENDIX IV

INSTRUCTION HANDOUTS USED IN TROOP TRAINING AT FORT HOOD

Concept of Pattern Painting

1. All military vehicles and equipment have regular geometric configurations or characteristic shapes and interior shadows. These so-called signatures contrast with natural surroundings and make the object conspicuous. To make such items less conspicuous, these identifying characteristics of shape, shadow, and highlights must be disrupted in a manner that makes the military vehicle more difficult to perceive. Pattern painting contributes significantly toward disrupting the signature characteristics by using lusterless paint to reduce the glare of highlights; color to reduce contrasts with the soil and vegetation; and also to distort the vehicles' geometric lines and overall configuration. Pattern painting is an art and not a precise science. The camoufleur designs the pattern according to each vehicle's needs with color areas that cut off corners, avoid straight vertical and horizontal lines, and extend internal shadows similar to natural features and vegetation.

2. Pattern painting is not a magic cure-all camouflage technique. It materially reduces the threshold of visibility and recognition as a military object; it also provides an excellent base for further, more complete camouflage. The pattern-painted vehicle will require less effort to camouflage, if properly sited, than a solid-colored vehicle.

3. The theory behind this new experimental pattern painting design is to provide a system that by the changing of one or, at most, two colors can accommodate geographical and seasonal changes: for instance, changing the forest green to sand for desert operations or by changing the field drab to dark green and the sand to field drab for summer verdant terrains in temperate climates. The pattern as depicted may be used as a late fall and winter pattern in verdant terrains and terrains subject to drought or long dry seasons. By using the camouflage color chart in conjunction with the pattern painting design, a good standard coloration for almost every terrain can be achieved as indicated above.

4. Previously, the pattern-painting designs were made for specific locations, and changes of terrain or seasons required a repainting of the whole vehicle. These new designs will also lend themselves to "touch-up" painting without the unsightly mottling which results from touch-up painting of the current OD vehicles. Slight mismatches in color will not be as noticeable as they are on a solid-color vehicle except from very close inspection. Nor will minor abrasions and scaling of surfaces be as conspicuous except from very close inspection.

Vehicle Preparation

This step in the process is extremely important and should be supervised with the utmost care. All grease, oil, dirt, plastic letters, and stars, all loose and scaling paint, and paint other than the original enamel or laequer (such as latex paints, etc, which may have been used to retouch as an expedient) must be removed from the vehicle or aireraft. The vehicle must be cleaned with detergent or with solvent and rinsed thoroughly or steam-cleaned to insure a thoroughly clean surface suitable for a durable coating. The sanding of the rough areas to remove the oxidized surface from the old paint will also increase the quality and durability of the new paint job. Helicopters in addition to the normal kinds of surface dirt (oil, oxidation, dust, peeling, etc) are also coated with battery acid from the battery overflow vent. This acid must be neutralized with a bath of sodium bicarbonate (three handfuls per bucket of water). Wash the whold helicopter generously with this mixture and thoroughly rinse when finished. Anything less than this treatment will result in peeling, cracking, and scaling of your new coating. All glass, grease fittings, and items which can be damaged by paint must be masked with paper masking tape. Use grease for masking only as a last resort because it can be easily smeared onto other parts of the vehicle or helicopter and prevent paint adhesion.

Application of the Pattern to the Vehicle or Helicopter

Drawings for the vehicle are essential except where an expert camouflenr of considerable experience is available or where a smaple vehicle is available to be copied. Although precise measurement of pattern boundaries is not necessary, gross inaccuracies will result in a deterioration of effectiveness. The patterns are designed in such a way that tolerances of ± 1 inch (rule of thumb measurement) will not grossly affect the quality of the pattern. Care must also be exercised to avoid, wherever possible, straight, vertical, and horizontal lines. The pattern is applied to the vehicle with an abbreviation of its color to guide the painters. Subsequently, the painter must wipe the chalk marking off as he paints or it will show through the new paint job and cause poor adhesion along the chalk lines.

NOTE: Patterns for the painting of the fuselage and blades are attached as inclosures 1 through 4.

Paint

The paint used to pattern paint vehicles is a fast-drying, dull (lusterless), high-quality enamel. It may be obtained in the basic camouflage colors: light green, dark green, forest green, sand, desert sand, field drab, earth yellow, earth brown, olive drab, black, and white. The paint is manufactured under Specification TT-E-527, and the colors are specified under MIL-C-595. The paint may be applied by spray gun or brush (roller application is not recommended). The painter must make sure the newly painted

surface appears wet upon application to insure good adhesion and coverage. The paint may be applied to any metal surface. (When applied to a new metal surface, a wash primer is recommended to prepare the surface, MIL-P-328).

Lacquer

The lacquer is a high-quality acrylic nitrocellulose lacquer (MIL-L-19538C) and is the same as that prescribed for the painting of helicopters. It is prepared in the essential camouflage colors according to Federal Standard 595.

Enamel Mixing

1. Temperature and humidity will require adjustment of the mixture, paint to thinner ratios:

a. 30^{o} to 60^{o} – 3 gallons paint to 1 gallon Xylene*

b. 60^{o} to 80^{o} – 2 gallons paint to 1 gallon Xylene

c. Above 80^{o}, relative humidity 55% – 2 gallons paint to 1 gallon Xylene and 1 pint Butyl Cellosolve.**

d. If raining or hot above 80^{o} – 2 gallons paint to 1 gallon Xylene and 1 quart Butyl Cellosolve.

2. Paint drying time over a previously painted substrata at 75^{o} is approximately 50% dry to the touch in 30 minutes which is dependent on both temperature and humidity.

Lacquer Mixing

Temperature and humidity will require adjustment of the lacquer mix. The normal mix is 1 gallon lacquer to 5 quarts of thinner (cellulose nitrate). In unusually hot temperatures 80^{o} or more, add about 1 pint of thinner Cellulose-Nitrate-Dope Blush Retarding MIL-T-6095A, Fed Stk # 8010-162-5289. In rainy weather, it may be necessary to discontinue painting.

MIL-L-19538C Lacquer: Acrylic Nitrocellulose Camouflage (for aircraft use)

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*Xylene (Xylol).

**Butyl Cellosolve (Ethylene Glycol Mono Butyl Ether) Fed Stk #6810-281-2001.

Federal Standard 595A colors:

FG – Forest Green – Color #34079
FD – Field Drab – Color #30118
S – Sand – Color #30277
BL – Black – Color #37038

All lacquers are to be lusterless.

MIL-T-6095A Thinner Cellulose-Nitrate-Dope Blush Retarding Fed Stk #8010-162-5289.

The dull (lusterless) coating produced by the lusterless lacquer is further modified by the use of Walnut Pellets to create a diffuse surface (non-glare). The mix is one pound of Walnut Pellets to one gallon of unmixed lacquer (two gallon, one pint of mixed lacquer). This mix is used on the hub and rotor blades and other surfaces if necessary.

List of Items Essential at the Site for Pattern Painting of Vehicles and Helicopters:

1. Appropriate pattern design
2. Spray guns
3. Paint (lacquer or enamel)
4. Mixing buckets
5. Painter's masks
6. Masking tape to mask small items, etc.
7. Chalk
8. Brown (Kraft) Paper for masking windshields, etc.
9. Thinner (Xylene and Butyl Cellosolve or Cellulose Nitrate)
10. Water Separators and fittings with pressure gauge
11. Compressed air source
12. Detergent to clean vehicles
13. Paddles of sticks to mix paint
14. Paint brushes 1" and 3"
15. Rags
16. Appropriate wrenches for spray guns
17. Vehicles appropriately cleaned and masked for painting
18. Steel wool or sandpaper

Tips:

1. Vehicles must be clean of oil and dirt; otherwise, paint adhesion will suffer; and in the case of helicopters, also battery acid.

2. All loose or flaking paint must be removed and/or sanded.

3. The paint should be mixed in batches of 3 to 4 gallons and thoroughly stirred before each spray cup is filled.

4. Cover all grease fittings to prevent fouling.

5. The coating must be wet on application.

6. Paint gun adjustments must be made to insure proper paint and air mixture.

7. Compressors and water separators must be drained of water frequently.

8. All plastic letters and insignia must be completely removed and the surface cleaned.

9. Spray gun must be held close to work to prevent excessive overspray or a spray that is too dry.

10. Wipe chalk markings off the vehicle as paint is applied.

11. Don't walk over or abuse the coating while still tender or tacky.

12. Keep spray guns clean. It is advisable to run thinner through the gun prior to each filling or clean it is there are any signs of caking present.

13. Housekeeping in and around the paint mixing and filling area is very important.

14. Clean all spray equipment and brushes thoroughly at the end of each day.

15. Cover paint cans and pots to prevent a skin forming on the paint.

16. Thoroughly stir all new cans of paint prior to mixing.

Colors for Enamel and Lacquer Federal Standard 595 Color No.

Sand #30277	Black #37038
Field Drab #30118	Forest Green #34079

1) Enamel—TT-E-527—Enamel, Alkyd, Lusterless: no FSN number for the colors that were designated.

2) Lacquer—Mil-L-19538C, Lacquer, Acrylic-Nitrocellulose, camouflage (for aircraft use) for black 8010-527-2884.

3) Butyl Cellosolve—TT-E-776b—Ethylene Glycol Monobutyl Ether (for use in organic coatings) 6810-281-2001—1 gal can.

4) Canvas Paint—TT-P-595A—Preservative Coating, Canvas: no FSN.

5) Lacquer Thinner—TT-T-266b, Thinner: Dope and Lacquer (Cellulose-Nitrate). 8010-160-5789—for 55 gal drums 8010-160-5787 1 gal cans.

6) Xylene—TT-X-916 Xylene (for use in organic coatings). 6810-584-4070—for 5 gal drum; 6810-290-4166—for 55 gal drum.

7) Blushing-Retardant—MIL-T-6095B. Thinner: Cellulose-Nitrate-Dope, Blush-Retardant 8010-162-5289.

8) MIL-T-704E—Treatment and Painting of Materiel.

9) Ground Walnut Shell #28 (Maximum of 1% retained on 40 mesh screen)

(Cost $.20 lb): Supplier:

Bernard Sirotta Co., Inc.
33, 35th Street
Brooklyn, NY

LIST OF ITEMS ESSENTIAL AT THE SITE (UNIT) FOR INSTRUCTION IN PATTERN PAINTING

QUANTITY	ITEM
2 or more	Spray Guns
1-Week supply	Paint
12	Mixing Buckets or Pails
100	Painters Masks for all individuals working in the area
15 to 20 rolls	Assorted 1" and 2" masking tape 10 1" and 5 2" is appropriate
3 dozen	Sticks of chalk (Schoolroom sticks)
Roll 50 lb approximately	Brown wrapping paper for masking (or a substitute)
1 week supply based on gallons of paint supplied	1 thinner to 2 gallon paint and 2 gallon for brush and spray gun cleaning
As necessary	Coupling for hose attachments to guns and air supply
	Compressed air source 60 psi for at least 2 guns
As required	Detergent to clean vehicles
12	Sticks or paddles for paint mixing
6 – 3" Brushes 6 – 1" Brushes 6 – ½" Artist Brushes	Paint brushes for brush painting instruction and use where spray painting can be supplemented.
Bundle as necessary	Rags for cleaning of equipment and hands
3 to 4	Vehicles appropriately cleaned ready for painting
If possible	Regulator (pressure with water separator) to regulate air pressure and take out excess moisture (water) from compressed air
As necessary	All grease fittings on vehicles must be appropriately greased to prevent fouling by paint

PAINT FOR NEOPRENE COATED TARPS
(GAMMA GOAT)

Use the same paint (enamel) as you applied to the metal. However, to insure adhesion and flexibility without cracking, a 3rd ingredient must be mixed with the enamel. The coating will stay tackie for a period of 12-20 hours dependent on the weather.

MIX: The paints (enamel) must be thoroughly stirred before mixing with thinner to insure complete dispersion of the pigment and dulling agents. Mix ½ pt lacquer retardent to 1 gallon of xylene, stir thoroughly. Mix 2 gallons of paint (enamel) to the mixed xylene (1 gallon) - lacquer retardent (½ pt) and stir thoroughly to insure good dispersion.

NOTE: It is important to stir the paint mix each time a spray gun cup is filled to make sure the coating has sufficient pigment and dulling agent in it to satisfactorily coat the fabric.

SPECIFICATIONS:

TT-E-527	Enamel, Alkyd, Lusterless	NO FSN
TT-X-916b	Xylene (for use in organic coatings)	
	FSN: 6810-584-4070	5 gal. cans
	6810-290-4166	55 gal. drums
MIL-T-6095B	Thinner, Cellulose-Nitrate-Dope, Blush-Retardant	
	FSN: 8010-162-5289	

COATING FOR TARPS (Pattern Painting)

COTTON DUCK (CANVAS) CANVAS PAINT

This paint is an impregnant and preservative colored with pigment in camouflage colors. The paint dries to a flexible coating and stays soft similar to the consistency and feel of paraffin wax. The coating sinks into the canvas. The surface of the cloth should not be completely filled – the rough cloth texture should still be visible.

MIX: The paint should be thoroughly stirred before mixing with thinner. Mix, 1 quart xylene to 1 gallon of canvas paint. If the paint remains a little too thick to spray, add an additional pint of the xylene to the mixed paint.

NOTE: The forest green has a higher concentration of pigment and may require a greater amount of thinner than other colors.

SPECIFICATION:

TT-P-595A	Preservative Coating, Canvas. NO FSN
TT-X-916b	Xylene (for use in organic coatings) FSN: 6810-584-4070 —— 5 gal. cans 6810-290-4166 —— 55 gal. drums

VOLATILE SUBSTANCES

SOME QUESTIONS AND ANSWERS

Many volatile liquids produce an intoxicated state when inhaled. Young children and adolescents have experimented with this method of distorting consciousness; others have become habituated to the effects of some inhalant. At present, the use of commercial solvents, of which airplane glue is the most popular, may be on the decline. Use of aerosols from spray cans, however, appears to be increasing. The magnitude of the problem is difficult to determine. In large cities, a few thousand cases come to the attention of the school or enforcement authorities each year.

WHICH CHEMICALS ARE INHALED TO PRODUCE AN ALTERED STATE OF CONSCIOUSNESS?

A wide variety of industrial solvents, anesthetics, and other chemicals produce intoxication or coma. They can be divided into three groups:

1. COMMERCIAL SOLVENTS. Toluene, xylene, benzene, naptha, hexane, acetone, trichlorethylene, carbon tetrachloride, and many other volatile solvents are found in model airplane glue, plastic cements, paint thinner, gasoline, cleaning fluids, nail polish remover, and cigarette lighter fluid.

2. AEROSOLS. The propellants in many household and commercial aerosols sprays are gases containing chlorinate or fluorinated hydrocarbons. Aerosols that have been abused include insecticides, deodorants, glass chillers, and hair sprays.

3. ANESTHETICS. Infrequently, chloroform, ether, and nitrous oxide (laughing gas) have been misused in recent years. Nitrous oxide is available commercially as a tracer gas to detect pipe leaks, as a cream whip propellant, and to reduce pre-ignition in racing cars.

What are the DANGERS of the inhalants?

All the inhalants share the hazards of inducing an intoxicated state in which judgment and motor functioning are impaired. Accidents, some fatal, have repeatedly occurred. Suffocation is the major cause of death. Typically, this occurs when the user becomes unconscious with the apparatus used still covering his nose and mouth.

APPENDIX V

MIL-E-

DRAFT SPECIFICATION
ENAMEL, ALKYD, CAMOUFLAGE

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers a quick drying, synthetic, camouflage alkyd enamel for use as a finishing coat on military equipment.

1.2 Classification.

1.2.1 Colors. The coating shall be of the following colors, as specified:

Light Green	Sand
Forest Green	Earth Brown
Dark Green	Earth Red
Olive Drab	Desert Sand
Field Drab	Black
Earth Yellow	

2. APPLICABLE DOCUMENTS.

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

TT-P-143	– Paint, Varnish, Lacquer, and Related Materials; Packaging, Packing and Marking of.
TT-T-291	– Thinner, Paint, Volatile Spirits (Petroleum Spirits)
TT-T-306	– Thinner, Synthetic Resin, Enamel
TT-R-266	– Resin, Alkyd; Solutions
TT-P-442b, III	– Pigment, Titanium Dioxide (For Protective Coatings)
TT-P-458	– Pigment, Yellow Iron Oxide; Hydrated, Synthetic, Dry Type III

TT-P-375, Type II	– Pigment, Bright Red (Iron Oxide)
TT-P-347	– Pigment, Chromium-Oxide-Green, Dry
TT-P-346b, Type III	– Pigment, Chrome-Yellow, Dry

Military

MIL-A-15197A	– Antimony Sulfide (Pigment)
MIL-T-704	– Treatment and Painting of Materiel

Federal Standards

Fed. Test Method Std. No. 141	– Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling, and Testing

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.)

(Single copies of this specification and other product specifications required by activities outside the Federal Government for bidding purposes are available without charge at the General Services Administration Regional Offices in Boston, New York, Washington, D.C., Atlanta, Chicago, Kansas City, Mo., Fort Worth, Denver, San Francisco, Los Angeles, and Seattle, Washington.)

(Federal Government activities may obtain copies of Federal Specifications, Standards and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

American Society for Testing and Materials Publications.

G26 – Operating Light and Water Exposure Apparatus (Xenon-Arc Type) for Exposure of Non-Metallic Materials.

D34 – Chemical Analyses of White Pigments.

Table I. Color and Reflectance Requirements

Color	Visual (Y)	Chromaticity		Infrared[1]		Magenta[1] Red Region		Allowable[2] Ratio
		x	y	Min	Max	Min	Max	Min
Light Green	0.098-.123	0.367	0.413	50.0	65.0	7.0	11.0	5.0
Forest Green	0.058-.075	0.333	0.357	45.0	60.0	5.5	7.0	5.5
Dark Green	0.071-.091	0.339	0.390	45.0	60.0	6.0	8.0	5.0
Olive Drab	0.061-.080	0.357	0.373	45.0	60.0	7.0	9.0	5.0
Field Drab	0.093-.117	0.390	0.383	25.0	35.0	–	–	–
Earth Yellow	0.225-.266	0.420	0.395	30.0	40.0	–	–	–
Sand	0.280-.327	0.360	0.366	55.0	65.0	–	–	–
Earth Red	0.087-.110	0.423	0.377	15.0	25.0	–	–	–
Earth Brown	0.071-.091	0.376	0.363	10.0	25.0	–	–	–
Desert Sand	0.300-.350	0.360	0.346	35.0	50.0	–	–	–
Black	0.030-.041	0.310	0.315	0.0	15.0	–	–	–

(1) See Table VII for wavelength definition.

(2) The ratio is calculated by dividing the value of the infrared by the value of the red spectral range.

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa.)

3. REQUIREMENTS.

3.1 Materials. The materials used in the enamel shall be as specified herein. Material not specified shall be selected by the supplier and shall be subjected to all provisions of this specification.

3.2 Color. The color compound shall impart to the substrate the required spectral reflectance properties in the visible (380-700 nanometers) and near infrared (700-1020 nanometers) spectrums. The color of this system shall be such that the trichromatic coefficients (x and y coordinates) shall fall within 2 N.B.S. units of those specified, and all reflectance values shall fall within the limits specified in Table I.

3.3 Composition.

3.3.1 Pigment. The pigments or any combination thereof, listed in Table II, shall make up the primary hiding pigmentation for the colors specified. Hiding pigments shall be chemically pure and free from extenders. The titanium dioxide shall be a rutile, chalk-resistant type conforming to Type III of TT-P-442. Small amounts of other tinting pigments may be used when necessary to match the spectral characteristics if these additional pigments have good color stability. The extender pigments shall consist of one or more of amorphous silicas, precipitated, calcium carbonate, and magnesium silicate.

Table II. Pigmentation

Light Green	—	Cobalt Zinc, Cobalt Titanate,(1) Cobalt Aluminate,(2) Yellow Iron Oxide, Chrome Yellow, Red Iron Oxide, Antimony Sulfide.(3)
Dark Green	—	Cobalt Zinc, Cobalt Titanate, (1) Cobalt Aluminate,(2) Yellow Iron Oxide, Chrome Yellow, Red Iron Oxide, Antimony Sulfide.(3)
Forest Green	—	Cobalt Zinc, Yellow Iron Oxide, Red Iron Oxide, Antimony Sulfide.(3)
Olive Drab	—	Cobalt Titanate, Chrome Yellow, Red Iron Oxide, Antimony Sulfide.(3)
Field Drab	—	Chromium Oxide, Red and Yellow Iron Oxide, Titanium Dioxide, Carbon Black.

Table II. Pigmentation (Cont'd)

Earth Yellow	–	Yellow Iron Oxide, Red Iron Oxide, Chromium Oxide, Titanium Dioxide, Carbon Black.
Sand	–	Yellow Iron Oxide, Red Iron Oxide, Chromium Oxide, Titanium Dioxide, Antimony Sulfide.(3)
Earth Red	–	Yellow Iron Oxide, Red Iron Oxide, Carbon Black, Titanium Dioxide.
Desert Sand	–	Yellow Iron Oxide, Red Iron Oxide, Chromium Oxide, Titanium Dioxide, Carbon Black.
Black	–	Carbon Black, Lampblack, Bone Black.

(1) Cobalt Titanate comes in four colors: Dark, Light, Forest, & Olive Greens.
(2) Cobalt Aluminate comes in two colors: Turquoise and Dark Blue.
(3) Antimony Sulfide shall be used at no more than 7 percent of the entire primary pigment content.

3.3.1.1 Prime Pigment. The cobalt-type pigments shall meet the characteristics specified in Table III. Each gallon of enamel shall contain not less than 1.5 gallons per pound of the cobalt zinc, cobalt titanate, and/or cobalt aluminate. Upon pigment analysis as specified in 4.4.2, results shall show not less than 0.190 pound of cobaltous oxide pergallon of enamel. When only cobalt titanate is used, results shall show not less than 0.90 pound of titanium dioxide. A minimum of 75 percent of the total prime pigment content of the olive drab shall be cobalt titanate, 78 percent of the forest green shall be cobalt zinc, and 75 percent of the dark green and 65 percent of the light green shall be any combination of the cobalt-type pigments.

Table III. Prime Pigment Characteristics

	Cobalt Zinc		Cobalt Titanate		Cobalt Aluminate	
	Max	Min	Max	Min	Max	Min
Average particle size, microns.	1.20	0.80	1.55	1.25	1.10	0.80
Specific gravity		5.50		4.25		4.60
Oil absorption, pounds of oil per 100 pounds of pigment.		10.00		10.00		32.00
Hiding power, square centimeters per gram.		25.50		25.50		25.50

3.3.1.2 Extender pigment. Any combination of amorphous silica, calcium carbonate, or magnesium silicate shall not exceed 60 percent by weight of the total pigment.

3.3.2 Vehicle.

3.3.2.1 Composition–general use. The vehicle shall be a drying oil phthalic alkyd resin in mineral spirits, conforming to the requirements of Table IV, and the necessary additions of driers and volatile solvents. Small amounts of anti-skinning agents, wetting agents, suspension agents, and stabilizers may be used at the discretion of the manufacturer. The vehicle shall give a negative test for resin and phenolic resin. An alkyd resin conforming to TT-R-266, Type III or IV, or a blend thereof will meet these requirements.

Table IV - Characteristics of Alkyd Resin

Characteristics	Requirements	
	Minimum	Maximum
Total solids, percent by weight of alkyd resin solution	49	51
Viscosity (Gardner Bubble Viscometer)	U	Z-1
Color (Gardner Color Scale)	–	1/13
Phthalic anhydride, percent by weight of alkyd resin solids	30	–
Drying oil acids, percent by weight of alkyd resin solids	45	55
Unsaponifiable matter, percent by weight of alkyd resin solids		

1/ Gardner Color Tube in accordance with method 4248 of Fed. Test Method Std. No. 141.

3.4 Qualitative requirements.

3.4.1 Condition in container. The enamel, tested as in 4.4.9, shall be free of grit, seeds, skins, lumps, thickening, or livering and shall show no more pigment settling or caking than can be readily reincorporated to a smooth, homogeneous state.

3.4.2 Storage stability.

3.4.2.1 Partially full container. The enamel shall show no skinning when tested as in 4.4.10.1. After aging as specified in 4.4.10.1, the enamel shall show no livering, curdling, hard caking, or gummy sediment. It shall mix readily to a smooth, homogeneous state; any skin formation shall be continuous and easily removed.

3.4.2.2 Full container. The enamel, when tested as in 4.4.10.2, shall show no skinning, livering, curdling, hard-dry caking, or tough gummy sediment. The enamel shall remix readily to a smooth, homogeneous state and must be usable. The consistency of the enamel after storage shall be 67-86 K.U.

3.4.3 Dilution stability. When thinned as in 4.4.11, the enamel shall remain stable and uniform showing no precipitation, curdling, or separation. Slight pigment settling shall be permitted.

3.4.4 Brushing properties. The enamel, when tested as in 4.4.12, shall brush satisfactorily and shall dry to a smooth, uniform film, free from seeds, runs, sags, or streaks. The dried film shall show no discernible brush marks.

3.4.5 Spraying properties. The enamel, tested as in 4.4.13, shall spray satisfactorily in all respects and shall show no running, sagging, streaking, or pronounced orange peel. The air-dried film shall show no seeding, dusting, floating, fogging, mottling, hazing, or other film defects.

3.4.6 Odor. When the enamel is tested as in 4.4.14, the odor of the wet paint and of the film at any interval of drying shall not be obnoxious or objectionable.

3.4.7 Flexibility. A film of the enamel prepared and tested as in 4.4.15 shall withstand bending without cracking or flaking.

3.4.8 Knife test. A film of the enamel tested as in 4.4.16 shall adhere tightly to and shall not flake or crack from the metal. The film shall ribbon or curl from the metal on cutting, and the cut shall show beveled edges.

3.4.9 Recoatability. When the enamel is tested as in 4.4.17, recoating of a dried film shall produce no film irregularity.

3.4.10 Water resistance. A film of the enamel tested as in 4.4.18 shall show no wrinkling or blistering when examined immediately after removal from distilled water. When the enamel is examined 2 hours after removal, there shall be no excessive softening, whitening, or dulling. After 24 hours air drying, the portion of the panel which was immersed shall be almost indistinguishable with regard to hardness, adhesion, and general appearance from a panel prepared at the same time but not immersed and shall retain at least 90 percent of the 85° specular gloss of the comparison panel and remain within the spectral characteristics originally specified.

3.4.11 Hydrocarbon resistance. A film of the enamel tested as in 4.4.21 shall show no blistering or wrinkling when examined immediately after removal from the

hydrocarbon test fluid. When the enamel is examined 2 hours after removal, there shall be no excessive softening, whitening, or dulling. After 24 hours drying, the portion of the panel which was immersed shall be almost indistinguishable with regard to hardness, adhesion, and general appearance from a panel prepared at the same time but not immersed and shall retain at least 90 percent of the 85° specular gloss of the comparison panel and remain within the spectral characteristics originally specified.

3.4.12 Accelerated weathering. Samples of the enamel tested as in 4.4.19 for 300 hours shall show no cracking, no loss of adhesion, or no loss of more than 30 percent of the original 85° gloss. The color after weathering shall remain within 2.5 N.B.S. units of the original values, and the infrared reflectance, red region reflectance, and allowable ratio shall remain within those limits originally specified.

3.4.13 Toxicity. The product shall contain no benzene (benzol), chlorinated compounds, or hydrolyzable chlorine derivatives.

3.4.14 Hiding power (contrast ratio). A dry film thickness of 1 mil maximum of the enamel as in 4.4.7 shall have a dry film contrast ratio of 0.98.

3.5 Quantitative requirements. The quantitative requirements shall be as specified in Table V.

Table V. Quantitative Requirements of the Enamel

Characteristics	Requirements	
	Min	Max
Total solids, percent by weight of enamel	60	–
Pigment solids, percent by weight of enamel	41	–
Vehicle solids, percent by weight of enamel	19	–
Flash point, Pensky-Martens, closed cup, °F	85	–
Water, percent by weight of enamel	–	1.0
Coarse particles and skins, percent by weight of pigment	–	1.0
85° Specular gloss	–	2.0
Fineness of grind	5	–
Consistency: Package, Krebs Stormer shearing rate – 200 rpm		
Grams	125	175
Krebs units	67	77
Drying time		
Set to touch, hours	–	2
Dry hard, hours	–	8
Full hardness, hours	–	72
Baking		
Dry through 250° for equivalent heat treatment, minutes	–	45

3.5.1 Spectral reflectance of prime pigment. The spectral reflectance characteristics of cobalt zinc, cobalt aluminate, and cobalt titanate are shown in Table VI. Any deviation shall be not more than 2 N.B.S. units and shall be not more than a ± 10 percent deviation from the infrared reflectance specified. These values are generated as described in 4.4.5.1.

Table VI. Spectral Reflectance Characteristics of Prime Pigment

Pigment	Visual (Y)	Chromaticity Values x	y	Infrared (% Cyan)
Cobalt Zinc	6.51	0.275	0.350	55.00
Cobalt Titanate				
Dark Green	12.98	0.323	0.376	52.00
Light Green	13.75	0.334	0.386	50.00
Olive Drab	10.94	0.327	0.366	45.00
Forest Green	10.85	0.326	0.367	46.00
Cobalt Aluminate				
Turquoise	10.62	0.210	0.301	58.00
Dark Blue	9.91	0.197	0.231	58.00

3.5.2 Spectral reflectance of applied enamel. The spectral reflectance of the applied enamel shall be in accordance with Table I, and any deviation shall be not more than 2 N.B.S. units as designated by Figs. 1-11.

4. QUALITY ASSURANCE

4.1 Responsibility for inspection. Unless otherwise specified in the contract or specification, the supplier is responsible for the performance of all inspection requirements specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for ther performance of the inspection requirements specified herein, unless disapproved by the government. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

4.2 Sampling, inspection, and testing of coating. Unless otherwise specified, sampling, inspection, and testing of enamel shall be in accordance with Fed. Test Method Std. No. 141, Method 1031.

4.3 Classification of tests. Inspection shall be classified as follows:

a. Quality conformance inspection (see 4.4).
b. Inspection of preparation for delivery (see 4.5).

4.4 Test Methods. The tests shall be conducted in accordance with Fed. Test Method Std. No. 141, except as otherwise specified herein. Test methods are shown in Table VIII. Failure to pass any test shall be cause for rejection of the lot which the sample represents.

4.4.1 Color. The applied enamel shall be tested for color in accordance with Method 4251 of Fed. Test Method Std. No. 141 using standard illuminant C. For the color test, the average of the measurements from six samples shall be used, none of which shall deviate more than two N.B.S. units from the center value and the average of which shall meet those requirements indicated in Table I. Failure to conform to these requirements shall constitute failure of this test.

4.4.2 Pigment analysis. Pigment analysis of the enamel shall be determined as follows:

4.4.2.1 Prime pigment content. Using approximately 200 ml of enamel measured to the nearest 0.1 ml, separate the pigment from the vehicle by using Method 4021 of Fed. Test Method Std. No. 141 or by drying the enamel and reducing the remaining contents (solids) to ash in a muffle furnace and determining the weight per gallon of extracted material. Using approximately half the ash or separated pigment which has been weighed to the nearest milligram, determine the titanium dioxide (TiO_2) in the ashed or extracted material in accordance with Fed. Test Method Std. No. 141, Method 7081 or 7082. Using the remaining sample weighed to the nearest milligram, determine by any recognized standard wet analysis or spectrographic method the cobaltous oxide (CoO) in the extracted or ashed material. If the values obtained are less than 1.10 pounds of titanium dioxide and 0.193 pound of cobaltous oxide per gallon of enamel, the sample shall have failed the test. For other permissible pigments, such as Antimony Sulfide, make appropriate qualitative and quantitative tests on the extracted pigment to determine if only permissible pigments and quantities were used in formulating the different colors.

4.4.2.2 Extender pigment content. Extract the pigment from a 200 ml sample of enamel in accordance with Fed. Test Method Std. No. 141, Method 4021, and analyze the extracted pigment for calcium carbonate in accordance with Method 7253, magnesium silicate in accordance with Method 7251, and amorphous silica in accordance with ASTM Designation D34-56T. If more than 60 percent by weight of the total pigments of one or a combination of these is present, the sample shall have failed.

4.4.3 Prime pigment particle size test. Using a portion of the prime pigment sample, determine the particle size of the prime pigment with a Fisher sub-sieve sizer. Nonconformance to the prime pigment particle-size requirement specified in Table III shall constitute failure of this test.

4.4.4 Hiding power of prime pigment.

4.4.4.1 Specimen preparation. Prepare a pigment in oil paste by thoroughly mixing the prime pigment in an oil made up of 100 grams of pale litho varnish No. 0, 1 gram of 24 percent lead naphthanate, and 2 grams of 6 percent cobalt naphthanate. The ratio of prime pigment to oil shall be 4:1.

4.4.4.2 Determination of hiding power. Determine the hiding power of the prime pigment by the Pfund Cryptometer method (black and white). A hiding power of less than 25.5 square centimeters per gram shall constitute failure of this test.

4.4.5 Spectral reflectance tests. Spectral reflectance of the enamel shall be determined as follows:

4.4.5.1 Prime pigment characteristics. Determine the spectral reflectance for the prime pigment in accordance with Fed. Test Method Std. No. 141, Method 4252, excluding the specular component. Make the measurements in the wavelength region between 400 and 900 nanometers using a Diano Hardy Spectrophotometer or other instrument that will perform the same type of measurement in the ranges that are required. These values are generated by dispersing the pigment in a vinyl resin, drawing down onto matte transfer paper, heat curing, and then releasing the coating from the paper and running the spectral curves on the lusterless side. Compare the results with Table VI. A deviation of more than that specified in 3.5.1 shall constitute failure of this test.

4.4.5.2 Applied enamel characteristics. Prepare specimens for the enamel reflectance test on a black and white Morest card. Apply the enamel to a 4-mil, dry-film thickness with a Boston-Bradley or a doctor blade. Determine the spectral reflectance for the enamel by the Diano Hardy Recording Spectrophotometer method in accordance with Fed. Test Method Std. No. 141, Method 6241. Compare the results with Table I. A deviation of more than 2 N.B.S. units in color space or deviation from the spectral limits in the visual, red, or infrared regions or the allowable ration shall constitute failure of this test. Measurements shall be made on the white portion of the Morest card.

4.4.5.3 Spectrophotometer method. For Method 6241, infrared reflectance values and red spectral reflectance values shall be obtained by averaging the reflectance percentages measured at wavelength ordinates given in Table VII.

Table VII. Selected Ordinates for Determining Infrared and Red Reflectance Values From Spectrophotometric Curves

Ordinates		
Red Region Nanometers	Infrared Region Nanometers	
620.0	714.0	793.0
626.0	725.0	797.0
638.0	730.0	802.0
645.0	737.0	807.0
649.0	742.0	811.0
652.0	747.0	816.0
653.0	751.0	821.0
655.0	756.0	826.0
658.0	760.0	831.0
663.0	764.0	836.0
	769.0	842.0
	773.0	848.0
	777.0	855.0
	783.0	862.0
	787.0	873.0

4.4.6 Vehicle analysis.

4.4.6.1 Unsaponifiable. Weigh by difference a sample of approximately 5 grams of the isolated vehicle into a 250-ml Erlenmeyer flask with a standard 24/40 joint and dissolve in 10 ml of benzene. Add 50 ml of 95 percent ethyl alcohol, 5 ml of 50 percent aqueous sodium hydroxide, and 5 ml of water. Mix thoroughly, attach an air condenser, and reflux gently in a water bath for 2 hours. Cool, transfer to a 500-ml separatory funnel, and dilute to 200 ml with water. Wash the flask with 100 ml of ethyl ether and transfer to the separatory funnel. Shake the funnel thoroughly and allow complete separation of liquid layers. Draw off the lower, aqueous layer and set aside for oil acids determination. Wash the ether extract about 5 times with 20-ml portions of water until neutral, and add all the washings to the aqueous portions already collected. Filter the ether through a rapid filter paper that is damp with ether into a weighed 250-ml beaker. Place a raised cover glass on the beaker and allow the ether to evaporate at room temperature (approximately 18 to 24 hours). Finally, dry the sample at 85°C in a vacuum oven for 1 hour. Cool and weigh the unsaponifiable. Dissolve the unsaponfiable matter

in 50 ml of 95 percent ethyl alcohol and add a few drops of phenolphthalein in a titrate with 0.1 N sodium hydroxide. Calculate the percent unsaponifiable using the following formula:

$$\text{Percent unsaponifiable (corrected)} = \frac{A - (B \times C \times 0.282) \times 100}{S \times N}$$

where: A = Weight of extracted unsaponifiable matter.
B = ml of NaOH used in the titration.
C = Normality of NaOH.
S = Weight of vehicle sample.
N = Vehicle nonvolatile fraction.

4.4.6.2 Drying oil acids. Transfer water layer and washings from the unsaponifiable in 4.4.6.1 to a separatory funnel, add 1-ml portions of concentrated hydrochloric acid followed by swirling until a permanent cloud forms; add 2 additional ml of acid followed by 100 ml of chloroform; and shake vigorously. After separation, transfer the lower chloroform layer to another separatory funnel. Repeat extraction of the aqueous layer with an additional 50 ml chloroform and combine the two chloroform extracts. Transfer the aqueous layer to a liter flask to be retained for the phthalic anhydride determination. Wash the combined chloroform twice with 200 ml of water and retain the water washings in the liter flask. Filter the chloroform through rapid filter paper that is wet with chloroform into a weighed 250-ml beaker. Evaporate the solvent in a water bath at 55°C with the aid of a gentle current of air and remove the beaker as soon as the solvent has evaporated. Dry the beaker containing the oil acids in a vacuum oven at 85°C to constant weight (about 2 hours). Calculate the percent oil acids on the nonvolatile vehicle basis. If white crystals can be observed in the isolated fatty acids, they may be isophthalic acid which will cause a high acid yield. A correction for such interference can be made by redissolving the oil acids in benzene, filtering into a weighed beaker, and redrying and calculating.

4.4.6.3 Phthalic anhydride. Dilute the combined aqueous layers and washings retained from 4.4.6.2 to 1 liter with water. Withdraw a 2-ml aliquot with a pipet and transfer to a 25-ml volumetric flask and dilute to the mark with 0.1 N hydrochloric acid. Using a prism spectrophotometer suitable for the ultraviolet region and a slit width of 0.6 mm, determine the absorbance at 276 mm with 0.1 N HCl in the reference cell. Apply the cell corrections if necessary. If the absorbance falls outside the range of 0.25 to 0.50, withdraw another aliquot of appropriate size and obtain a new absorbance reading. Calculate the concentration of phthalic anhydride in the aliquot as follows:

$$\text{Concentration (grams per liter)} = \frac{\text{absorbance}}{8.77 \times \text{cell length in cm}}$$

Calculate the percent of phthalic anhydride in the nonvolatile vehicle as follows:

$$\text{Percent phthalic anhydride} = \frac{1250 \times \text{concentration, g/liter}}{\text{nonvolatile sample weight}}$$

Note: The factor 1250 assumes the use of a 2-ml aliquot; if a larger or smaller aliquot is used, the factor is adjusted accordingly.

4.4.7 Hiding power (contrast ratio). Determine the hiding power (contrast ratio) in accordance with Method 4122 of Fed. Test Method Std. No. 141 using a film applicator which will deposit a 3-inch-wide film with a dry film thickness of 0.001 inch maximum. Air dry for 72 hours, then determine the reflectance and verify the film thickness in the area in which the reflectance was measured. Calculate the contrast ratio and check for compliance with 3.4.14.

4.4.8 Specular gloss. Draw down the enamel with a film thickness that is sufficient enough to completely hide the surface. Test as specified in Method 6101 of Fed. Test Method Std. No. 141 for compliance with Table V.

4.4.9 Condition in container. Determine package condition of the enamel in accordance with Method 3011 of Fed. Test Method Std. No. 141, and evaluate for compliance with 3.4.1. Reseal and agitate the can for 3 minutes on a paint shaker. On reexamination of the content, the disclosure of gel bodies, undispersed pigment, or unsatisfactory settling properties is cause for rejection.

4.4.10 Storage stability.

4.4.10.1 Partially full container. Determine skinning after 48 hours in accordance with Method 3021 of Fed. Test Method Std. No. 141, except use a 3/4 filled, 1/2 pint, multiple-friction-top can. Reseal and store for 7 days at 140°F and observe for compliance with 3.4.2.1.

4.4.10.2 Full container. In accordance with Method 3022 of Fed. Test Method Std. No. 141, allow a full standard quart can of the enamel to stand undisturbed for 1 year and then examine the contents. Evaluate pigment settling or caking, but agitate the can for 5 minutes on the paint shaker prior to re-examination. Make over applicable tests for compliance with 3.4.2.2.

4.4.11 Dilution stability. Reduce one part of enamel as packaged with one part by volume of thinner conforming to TT-T-291, grade 1. Then test in accordance with Method 4203 of Fed. Test Method Std. No. 141 for compliance with 3.4.3.

4.4.12 Brushing properties. Determine brushing properties in accordance with Method 4321 of Fed. Test Method Std. No. 141 for compliance with 3.4.4 using the enamel as packaged. For referee test for sagging, proceed as follows: Agitate the package enamel for 3 minutes on a paint shaker and then condition the sample at $23^{o} \pm 1.1^{o}C$ for 1 hour. Under referee testing conditions, draw down a film of the enamel, 2 inches wide and at least 6 inches long, with a 0.002 inch (0.004-inch gap clearance) film applicator on clear plate glass (Method 2021). Quickly draw a straight "paint-free" line completely across the middle length of the film by means of a steel ball bearing 1.875 ± 0.025 inches in diameter. Immediately place the panel in a vertical position for 2 hours air drying. Then observe whether any portion of the film above the sag line has run down over the line. Contact made by the enamel with the lower side indicates sagging.

4.4.13 Spraying properties. Reduce eight parts by volume of enamel with one part by volume of thinner conforming to TT-T-291. Spray on a steel panel to a dry film thickness between 0.0009 to 0.0011 inch and observe for spraying properly in accordance with Method 4331 of Fed. Test Method Std. No. 141 for compliance with 3.4.5. For referee test, use automatic application per Method 2131 of Fed. Test Method Std. No. 141. Determine 20^{o} specular gloss for both panels for compliance with 3.4.5.

4.4.14 Odor. Test for odor in accordance with Method 4401 of Fed. Test Method Std. No. 141, and observe for compliance with 3.4.6.

4.4.15 Flexibility. Determine flexibility in accordance with Method 6221 of Fed. Test Method Std. No. 141. Apply a 2-inch-wide film of enamel on a flat tin plate panel, prepared in accordance with Method 2012 of Fed. Test Method Std. No. 141, using the petroleum naphtha-ethylene glycol monoethyl ether mixture with a suitable film applicator that will give a dry film thickness of 0.0009 to 0.0011 inch. Air-dry in a horizontal position for 18 hours, and then bake for 4 hours at $221^{o} \pm 4^{o}F$. Condition the panel for 1/2 hour under referee testing conditions. Bend over a 1/4 inch mandrel. Examine the coating for cracks over the area of the bend in a strong light at 7-diameter magnification for compliance with 3.4.7.

4.4.16 Knife test. Perform the knife test in accordance with Method 6304 of Fed. Test Method Std. No. 141. Cut the film from the flat portion of the panel from the flexibility test (4.4.15) and observe the results for compliance with 3.4.8.

4.4.17 Recoating. Prepare the enamel as in Method 4061 of Fed. Test Method Std. No. 141. Air-dry for 24 hours under referee testing conditions. Apply a second coat

Table VIII

Characteristics	Requirements-Reference Para. & Tables	Applicable Tests	
		Fed. Test Method Std. No. 141	Para. Reference
Enamel:			
Color	3.2	4251	4.4.1
Condition in container	3.4.1	3011	4.4.9
Storage stability	3.4.2	3021, 3022	4.4.10
Dilution stability	3.4.3	4203	4.4.11
Brushing properties	3.4.4	4321	4.4.12
Spraying properties	3.4.5	4331	4.4.13
Odor	3.4.6	4401	4.4.14
Flexibility	3.4.7	6221	4.4.15
Knife test	3.4.8	6304	4.4.16
Recoatability	3.4.9	4061	4.4.17
Water resistance	3.4.10	6011	4.4.18
Hydrocarbon resistance	3.4.11	6011	4.4.21
Accelerated weathering	3.4.12	–	4.4.19
Toxicity	3.4.13	–	4.4.20
Hiding power	3.4.14	4122	4.4.7
Total solids	Table V	4041	–
Vehicle solids	Table V	4062	–
Flash point	Table V	4293	–
Water content	Table V	4081	–
Coarse particle	Table V	4092	–
Gloss	Table V	6101	4.4.8
Consistency	Table V	4281	–
Fineness of grind	Table V	4411	–
Drying time	Table V	4061	–
Spectral reflectance	3.5.2	6241	4.4.5.2
Vehicle:			
Total solids	Table IV	4041	–
Phthalic anhydride	Table IV	–	4.4.6.3
Dry oil acids	Table IV	–	4.4.6.2
Unsaponifiable	Table IV	–	4.4.6.1
Pigment:			
Prime pigment	3.3.1.1-Table III	4021, 7082	4.4.2.1
Extender pigment	3.3.1.2	4021, 7251, 7253	4.4.2.2
Pigment solids of enamel	Table V	4022	–
Spectral reflectance	3.5.1	4252	4.4.5.1
Hiding power	Table III	–	4.4.4
Particle size	Table III	–	4.4.3
Oil absorption	Table III	4191	–
Specific gravity	Table III	4181	–

crosswise to the first coat, and then air-dry or bake as before. Examine for compliance with 3.4.9.

4.4.18 Water resistance. Prepare a film of the enamel as in 4.4.17. Air-dry the enamel for 168 hours, then immerse in distilled water at $23^{O} \pm 1^{O}C$ for 18 hours in accordance with Method 6011 of Fed. Test Method Std. No. 141. At the end of the test period, remove and examine for compliance with 3.4.10.

4.4.19 Accelerated weathering. Prepare a film of the enamel as in 4.4.15 and air-dry for 72 hours. Expose the panel for 300 hours to accelerated weathering in accordance with ASTM Designation G-26-70, Type BH. Examine the exposed panel for chalking. Examine the panel for color change by measuring the directional reflectance (Method 6121) before and after exposure, and calculate the lightness index difference as described in Method 6122 of Fed. Test Method Std. No. 141. Examine for compliance with 3.4.12.

4.4.20 Toxicity. The manufacturer shall certify that the enamel contains no benzene (benzol), chlorinated solvents, or other volatiles which are toxicologically hazardous under normal conditions.

4.4.21 Hydrocarbon resistance. Prepare a film of the enamel as in 4.4.18. Air-dry the panels for 72 hours at $23^{O} \pm 1^{O}C$ in a hydrocarbon fluid conforming to TT-S-735, Type III, in accordance with Method 6011 of Fed. Test Method Std. No. 141. At the end of the test period, remove and examine for compliance with 3.4.11.

4.5 Inspection of preparation for delivery. The packaging, packing, and marking shall be examined and tested in accordance with TT-P-143.

5. PREPARATION FOR DELIVERY

5.1 Packaging, packing, and marking. The enamel shall be packaged, packed, and marked in accordance with TT-P-143. Packaging shall be level A or C and packing shall be level A, B, or C, as specified. The enamel shall be furnished in the size of container specified.

6. NOTES

6.1 Intended use. The enamel is a high grade air drying medium oil alkyd type intended to be used as a camouflage coating over new or previously painted surfaces. The treatment and painting shall be in accordance with MIL-T-704 when applied over bare metal. The enamel is a lusterless coating in 11 different camouflage colors which

exhibits excellent weather resistance, color retention, flexibility, and resistance to water and hydrocarbons.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this specification.
b. Color of paint required (see 1.2.1).
c. Level of packaging and level of packing required (see 5.1).
d. Size of container required (see 5.1).

6.3 Basis of purchase. The enamel covered by this specification should be purchased by volume, the unit being one U.S. gallon of 231 cubic inches at 68°F (20°C).

6.4 It is believed that this specification adequately describes the characteristics necessary to secure the desired material, and that normally, no samples will be necessary prior to award to determine compliance with this specification. If, for any particular purpose, samples with bids are necessary, they should be specifically requested in the invitation for bids and the particular purpose to be served by the bid sample should be definitely stated; the specification is to apply in all other respects.

6.5 Federal specifications do not include all types, classes, sizes, etc. of the commodities indicated by the titles of the specifications or which are commercially available but are intended to cover the types, etc. which are suitable for Federal Government requirements.

6.6 Sample formulas. The enamel procured under this specification is contemplated to be comparable in performance for the various color and spectral requirements to the following pigment compositions. However, the government assumes no responsibility for the acceptance of a product to be manufactured under an identical formulation.

NOTICE. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Constituents	Percentages										
	Light Green	Forest Green	Dark Green	Olive Drab	Field Drab	Earth Yellow	Sand	Earth Brown	Earth Red	Desert Sand	Black
Cobalt Zinc[1]	68.50	84.50	80.00								
Cobalt Titanate[2]				83.00							
Chromium Oxide TT-P-347					60.20	8.75	26.50				
Chrome Yellow TT-P-346b, Type III	16.35		6.20	6.00							
Yellow Iron Oxide, TT-P-458 Type III	8.10	6.55	6.55		26.00	49.80	16.00	77.40	80.90	12.30	
Red Iron Oxide, TT-P-375, Type II	1.05	2.85	0.75	4.00	11.50	2.75	2.50	15.60	17.10	3.05	
Antimony Sulfide MIL-A-15197A	6.00	6.00	6.50	7.00							
Carbon Black					0.30	0.20		7.00	2.00	0.65	100.00
Titanium Dioxide TT-P-442b, Type III					2.00	38.50	55.00			84.00	

[1] Ferro Corporation, Cleveland, Ohio - Designation No. 0-1618.

[2] Ferro Corporation, Cleveland, Ohio - Designation No. K-637.

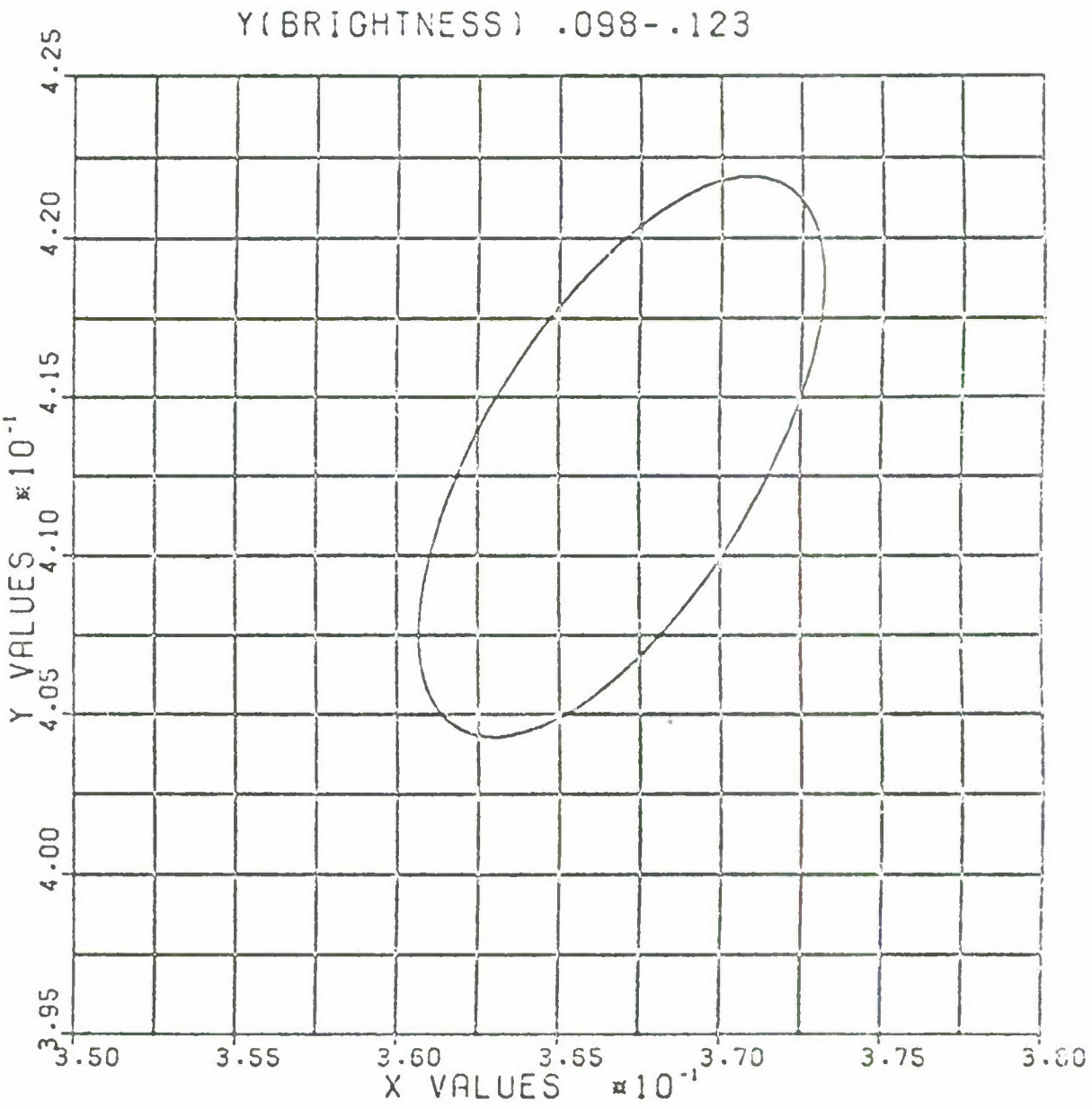

FIGURE 1

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT

COLOR- LIGHT GREEN

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

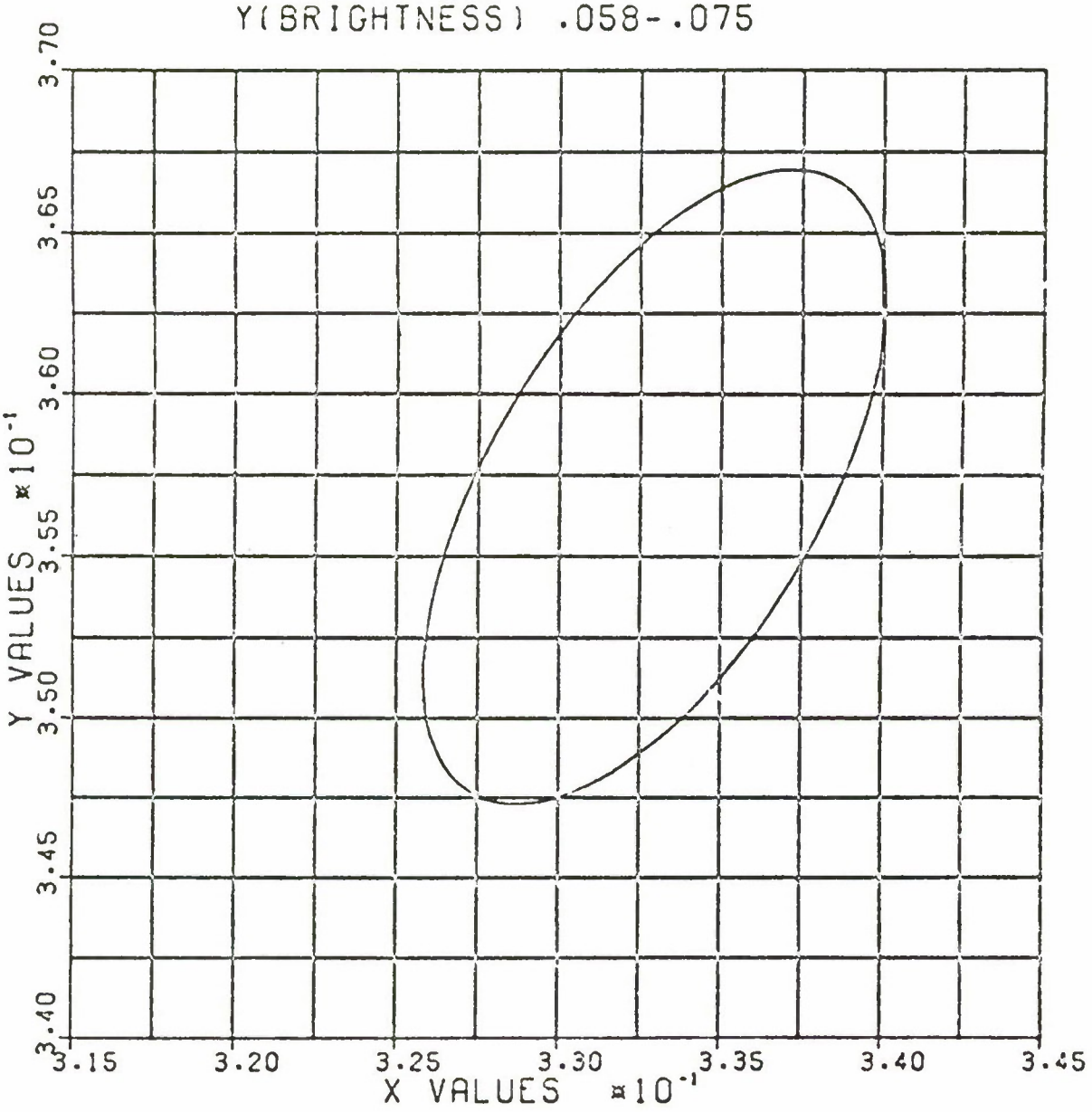

FIGURE 2

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT

COLOR- FOREST GREEN

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

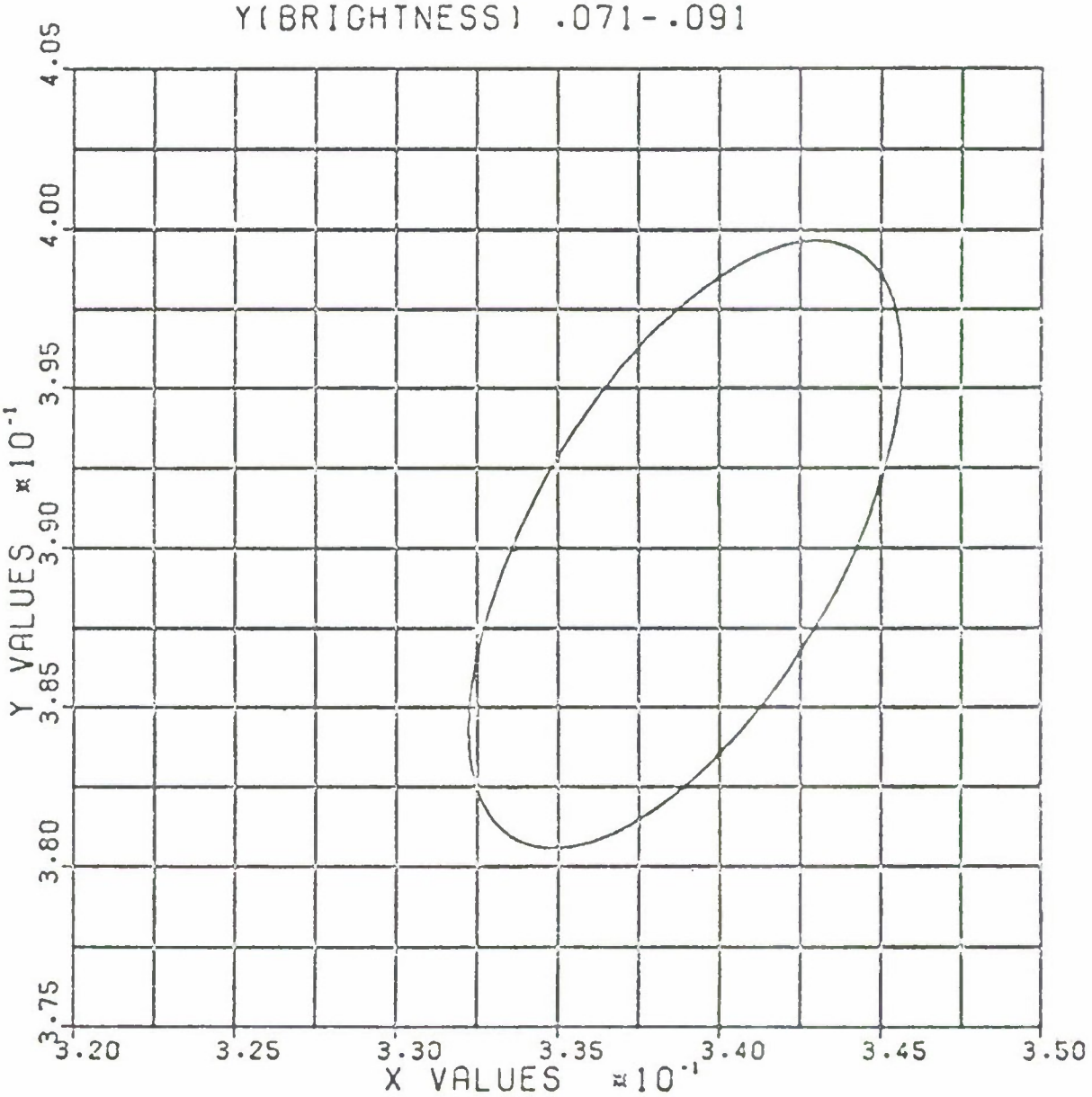

FIGURE 3

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT

COLOR- DARK GREEN

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

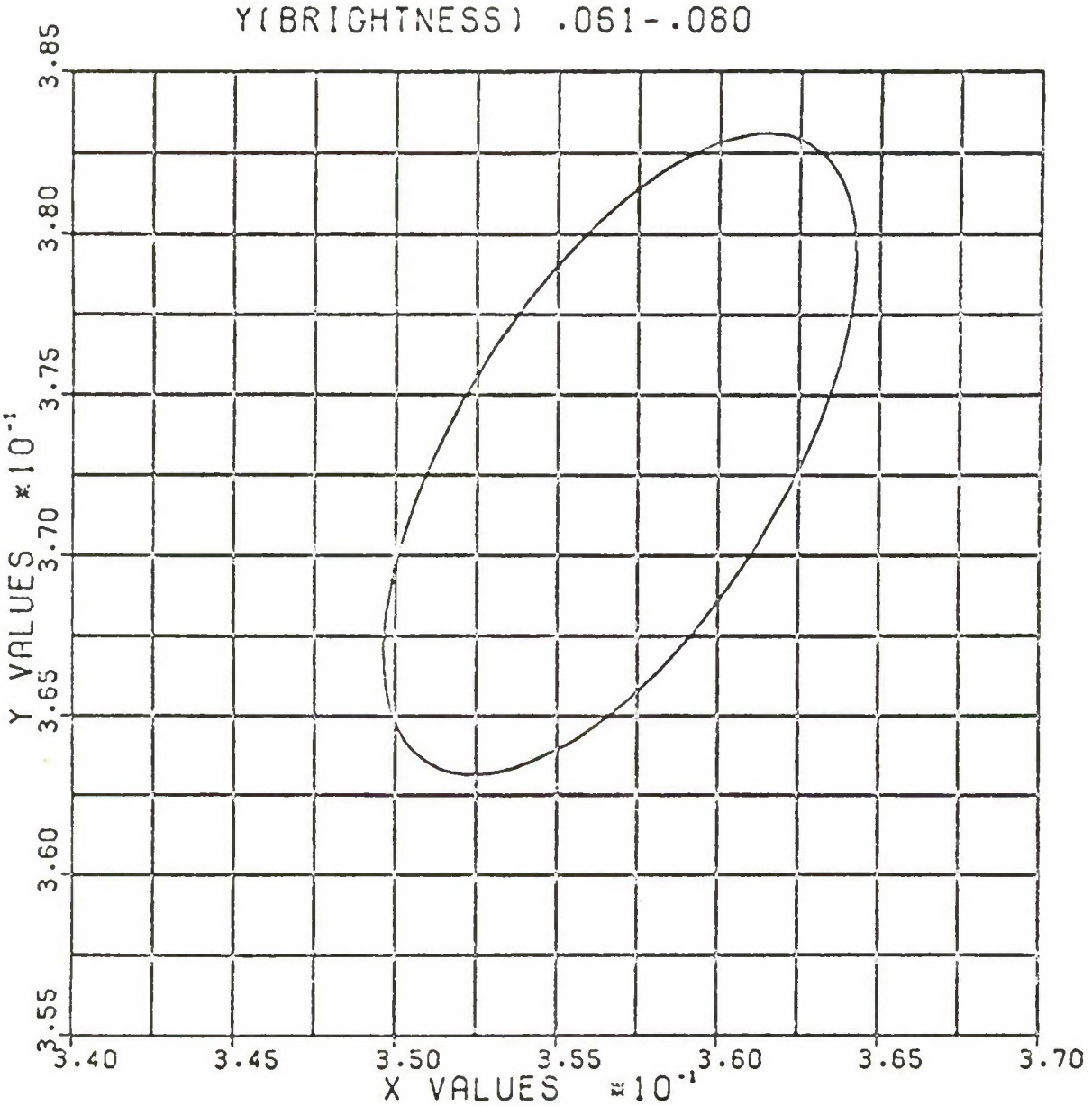

FIGURE 4

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT COLOR- OLIVE DRAB

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

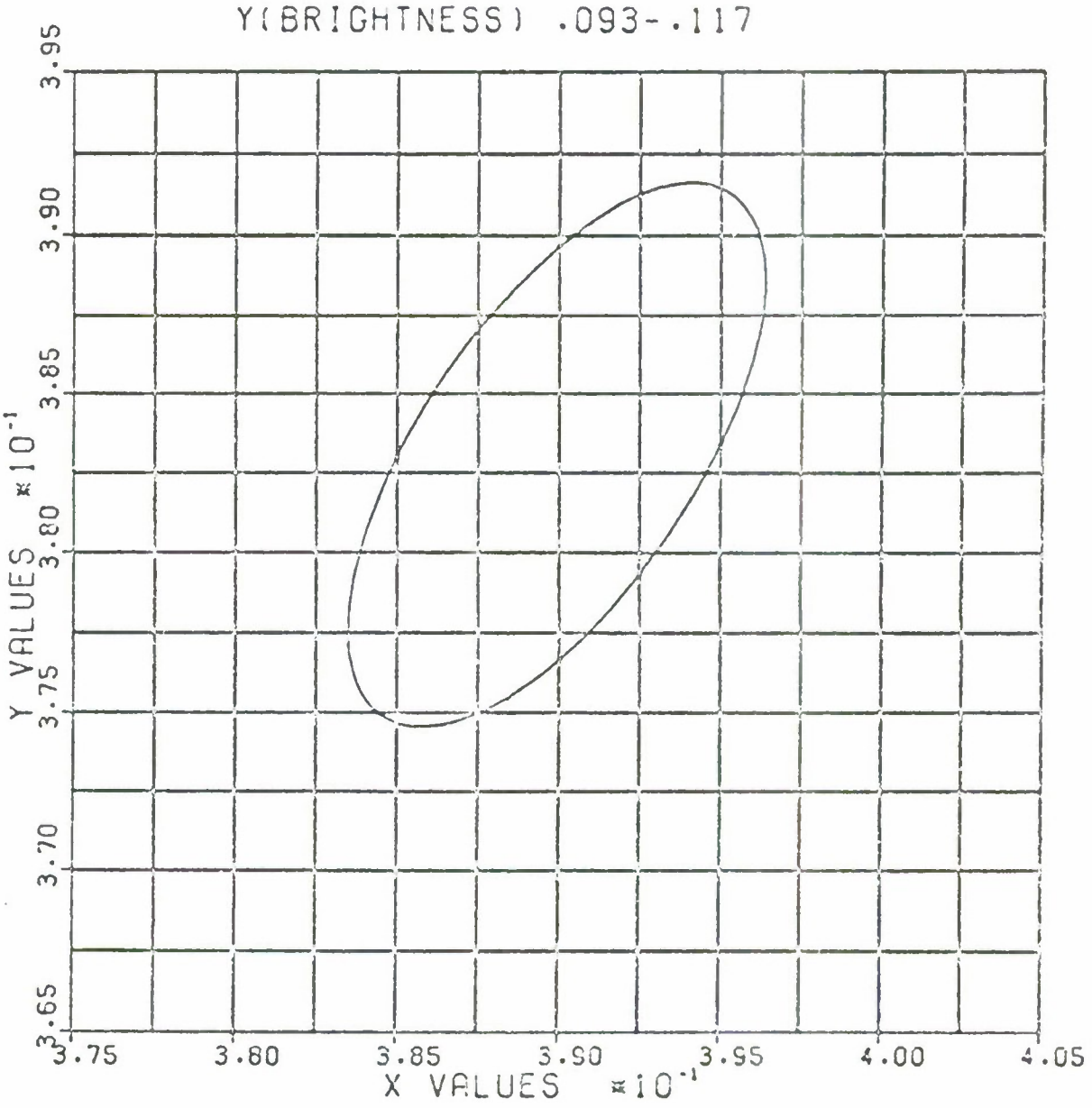

FIGURE 5

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT

COLOR- FIELD DRAB

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

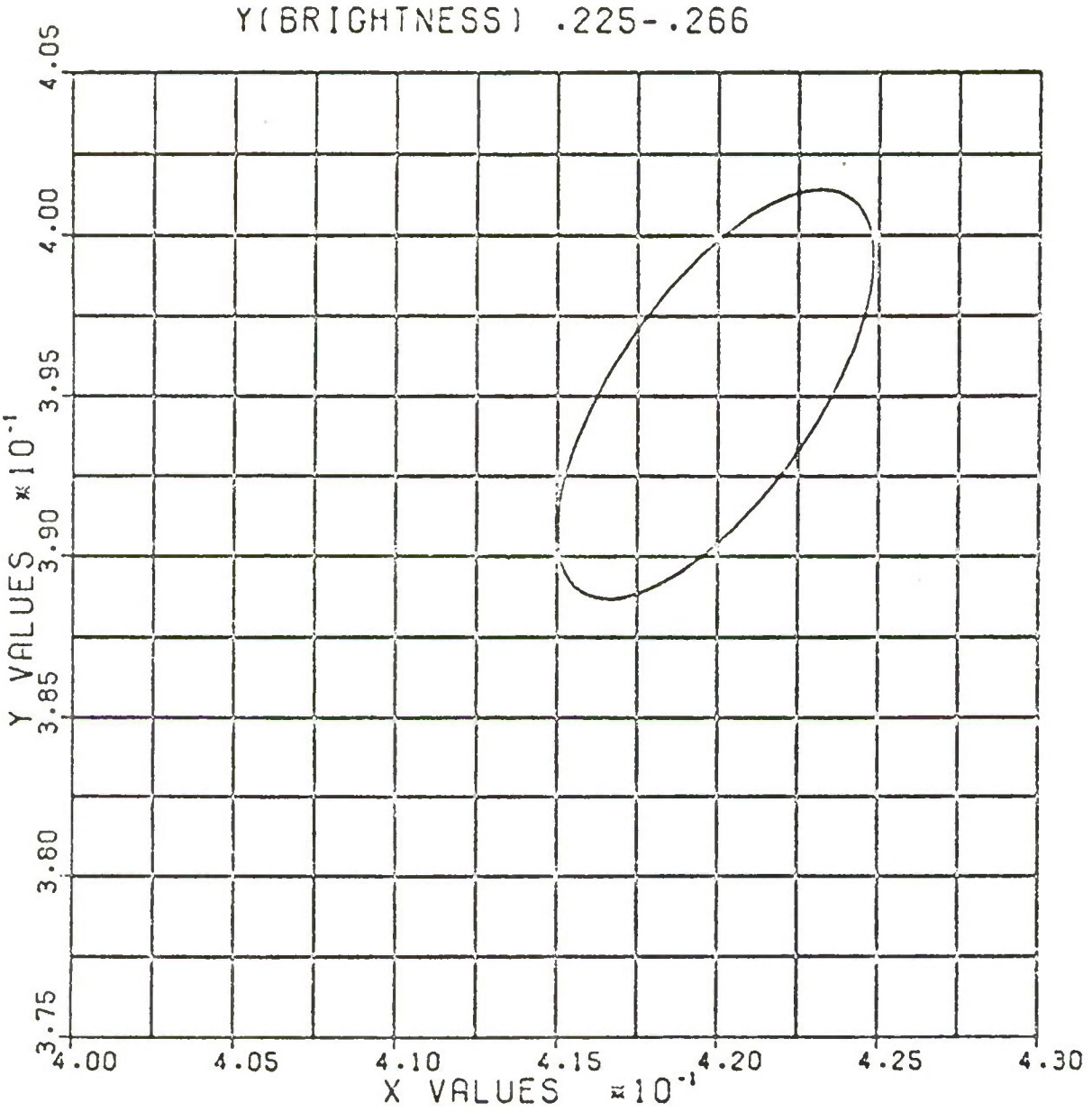

FIGURE 6

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT

COLOR- EARTH YELLOW

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

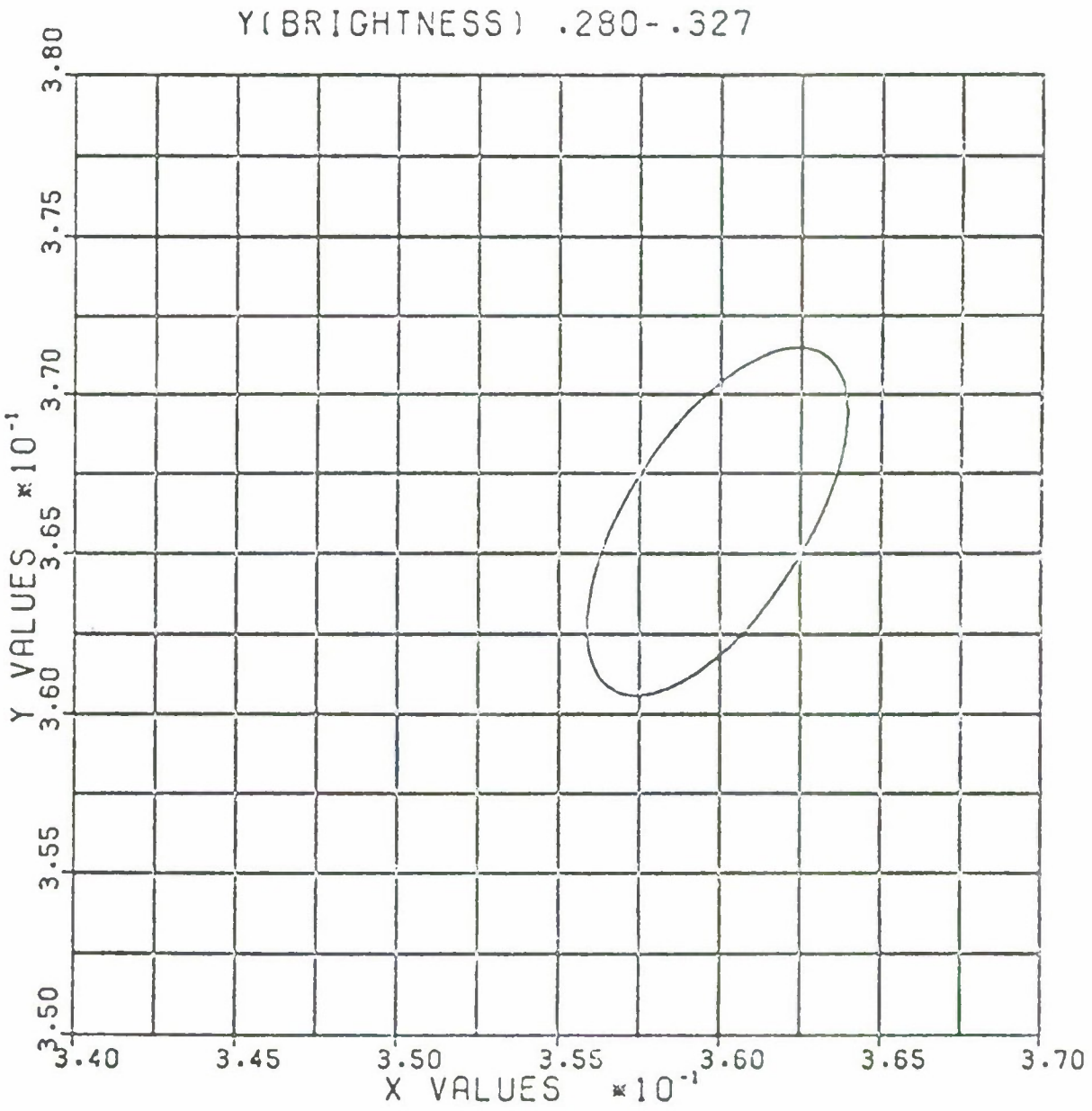

FIGURE 7

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT

COLOR- SAND

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

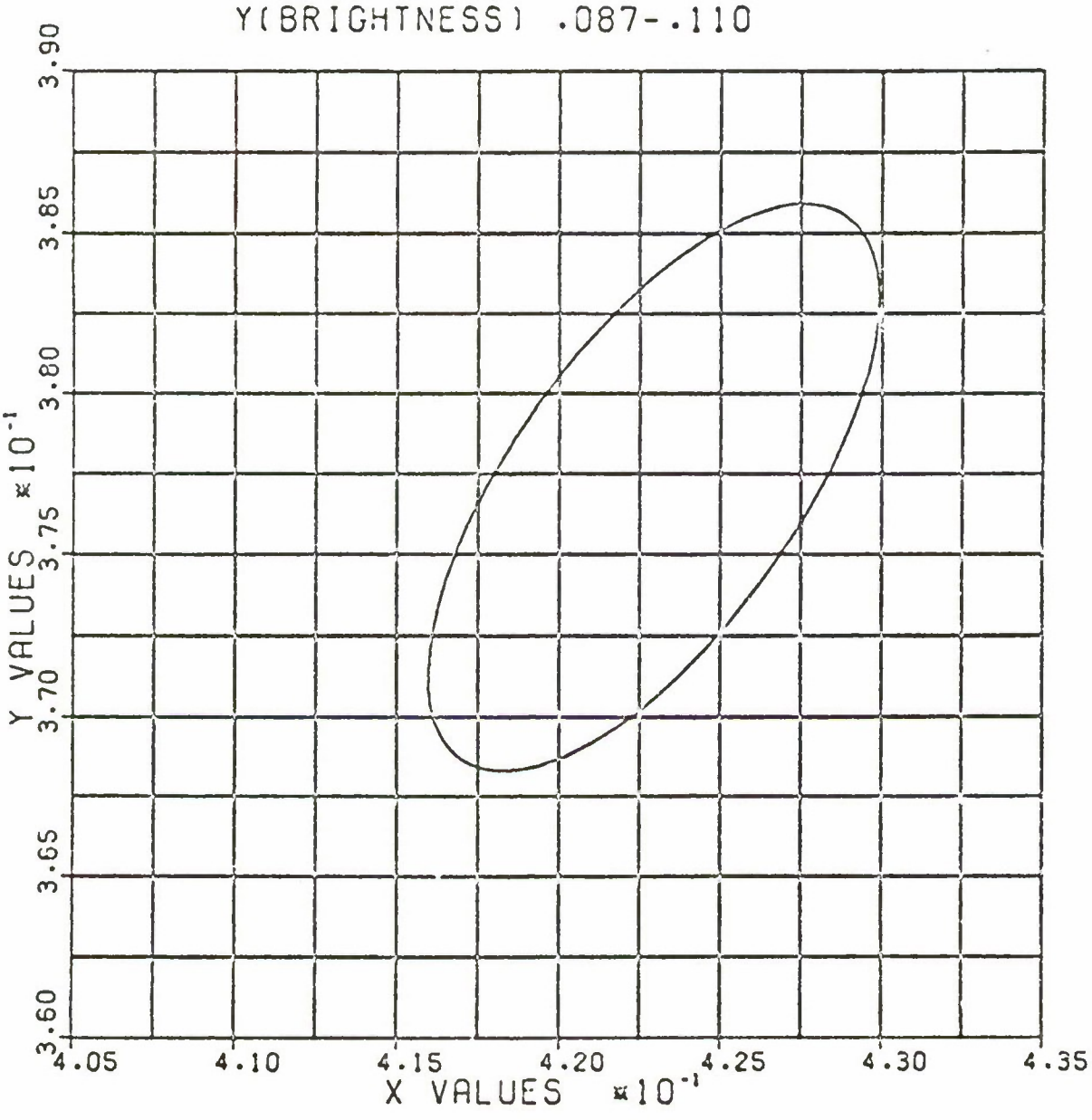

FIGURE 8

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT COLOR- EARTH RED

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

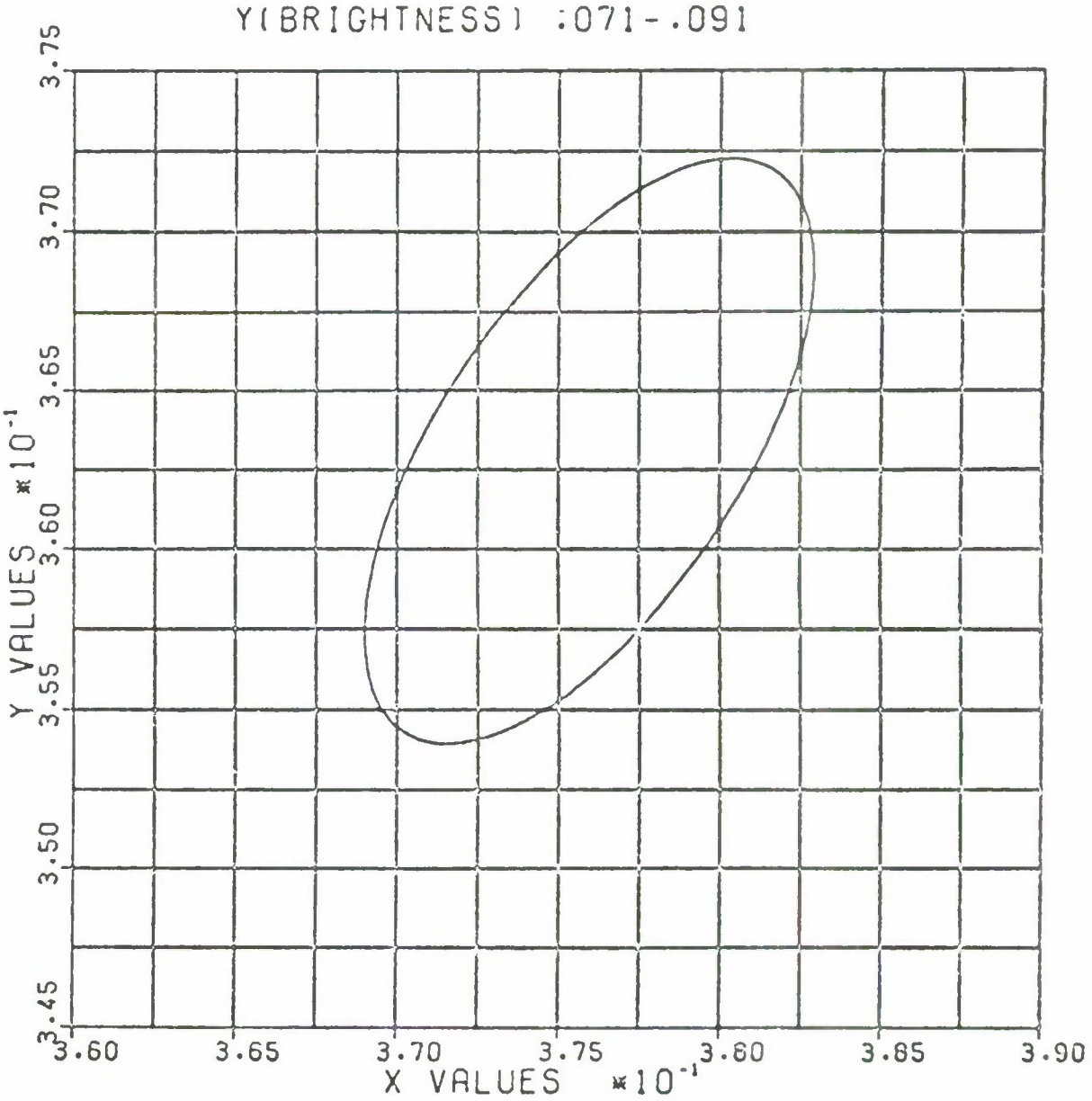

FIGURE 9

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT COLOR- EARTH BROWN

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

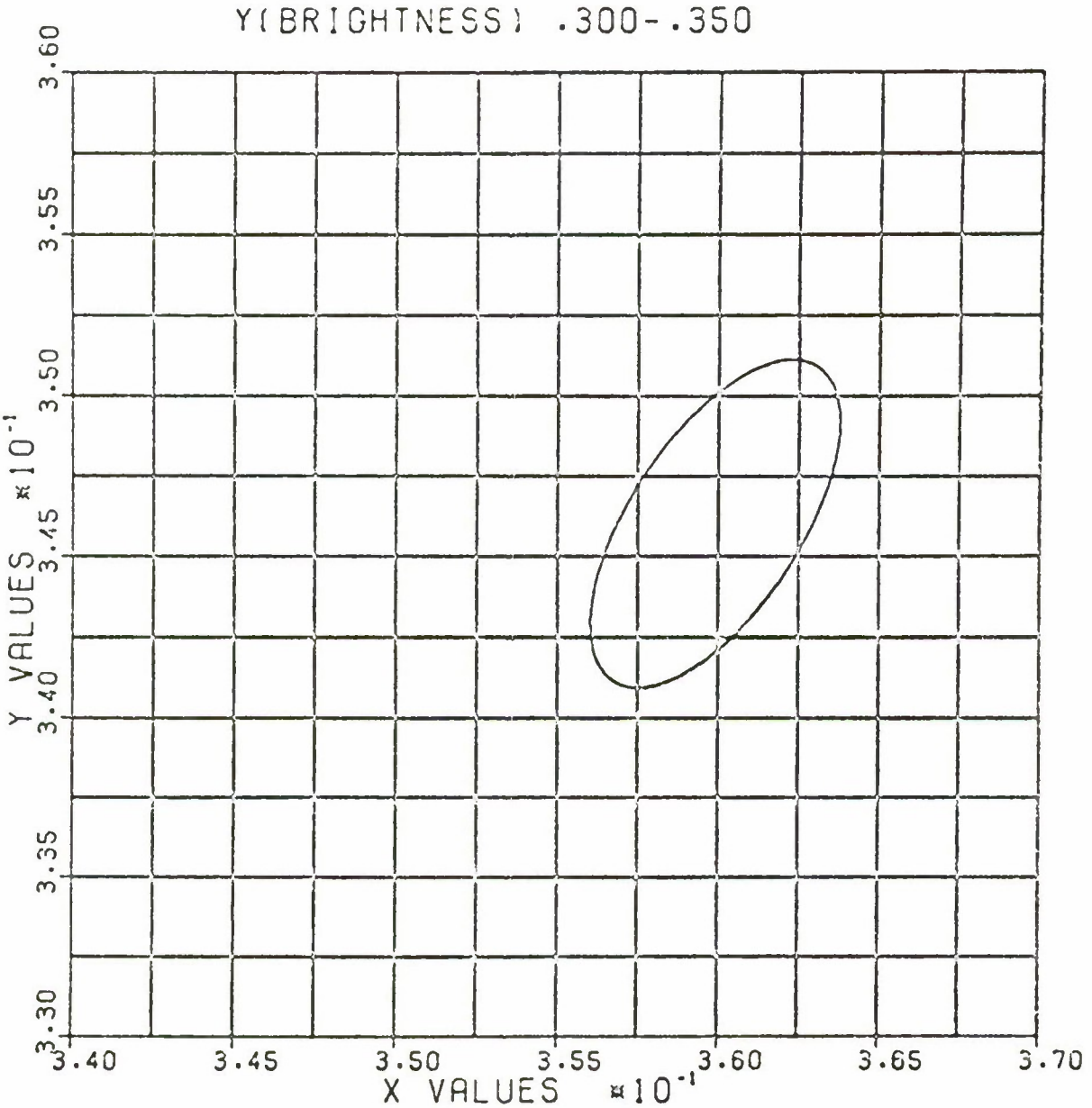

FIGURE 10

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT COLOR- DESERT SAND

NOTE-COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES.

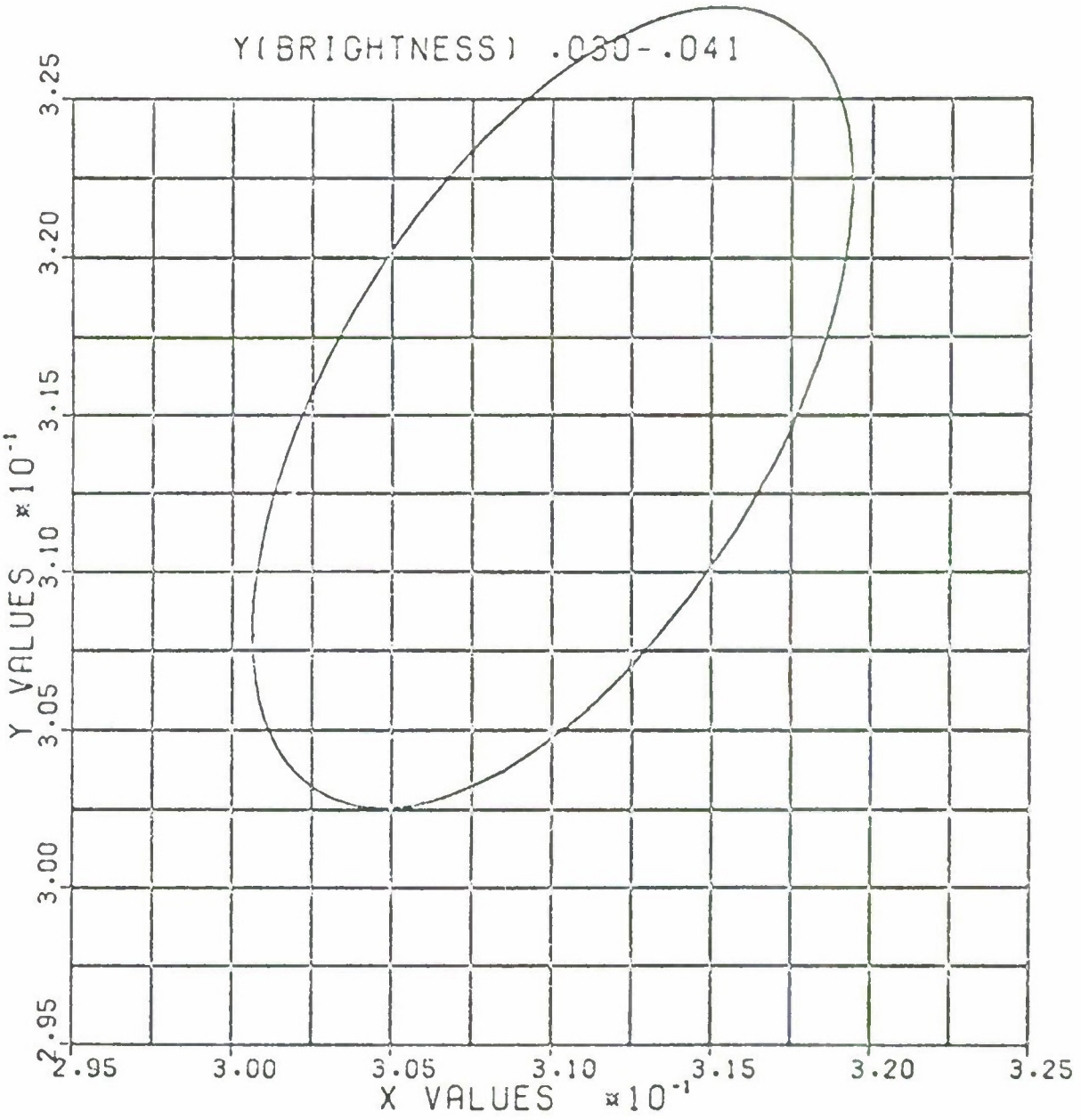

FIGURE 11

CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT COLOR- BLACK

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